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Ballast

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BALLAST



A reprint of one of
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Track Course Lessons

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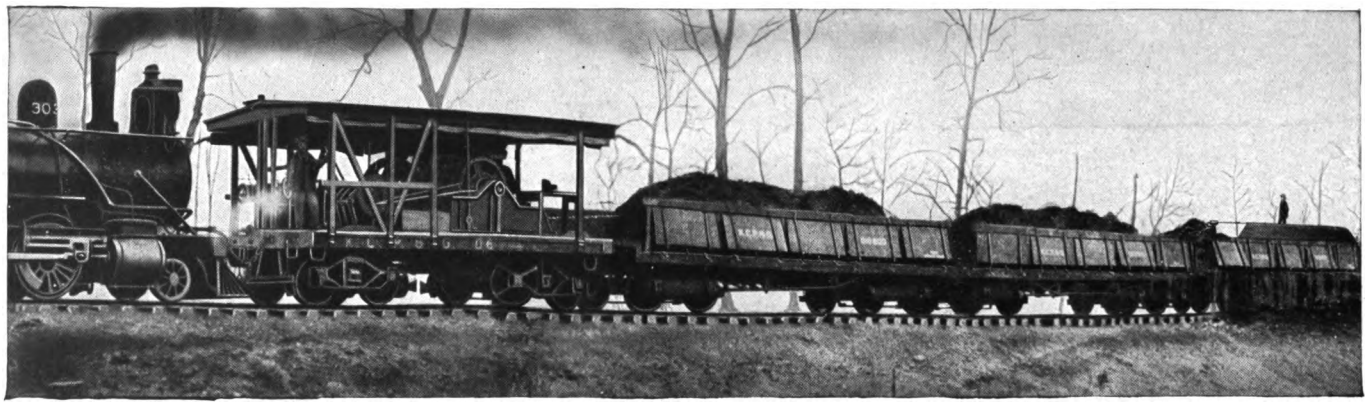
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FRONTISPIECE

The Lidgerwood Unloader, and ballast cars to be unloaded

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BALLAST

1. BALLAST is some material such as BROKEN STONE, GRAVEL, SLAG, CINDERS, BURNT CLAY, etc., which is placed on the finished roadbed to form a support for the ties, to provide a means of draining water away from them, and to make it possible to surface or raise track or make tie renewals, without disturbing the roadbed. When properly placed, ballast provides a firm and even bearing for the ties by evenly distributing the pressure due to the weight and thrust of trains passing over the track.

2. A good ballast material will provide good drainage that will prevent water from collecting and being retained around the ties, permitting it to pass to the roadway and be led away or absorbed. It will also reduce to a considerable extent the heaving due to frost, which will occur in freezing weather if proper drainage is not provided. Also, a good ballast material makes track work possible at nearly all seasons of the year, if necessary to correct line and surface. Good ballast materials being reasonably free from dust and dirt will not encourage a growth of weeds on the track, and if there is little dust or dirt there will be less wear to journals of rolling stock. Any ballast which will meet all of the foregoing requirements may be regarded as practically ideal; and the value of a ballast material is proportional to the extent to which it meets these requirements.

3. Many different materials have been, and are at the present time, used for ballast, among which may be mentioned:

BROKEN STONE	SAND
GRAVEL (of various kinds)	DECOMPOSED GRANITE
CINDERS	STONE SCREENINGS
SLAG	OYSTER SHELLS
CHATS	BURNT CLAY
CHERT	ORDINARY EARTH

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The Engineering Department of nearly every railroad issues a book of rules giving the practices of its track department. Such rules usually specify the various ballast materials which the road uses, and the standard requirements for each particular kind of ballast.

BROKEN STONE

4. The ballast material which, in the greatest degree, fulfils the requirements of an ideal ballast is BROKEN STONE. Broken stone ballast consists of stone which has

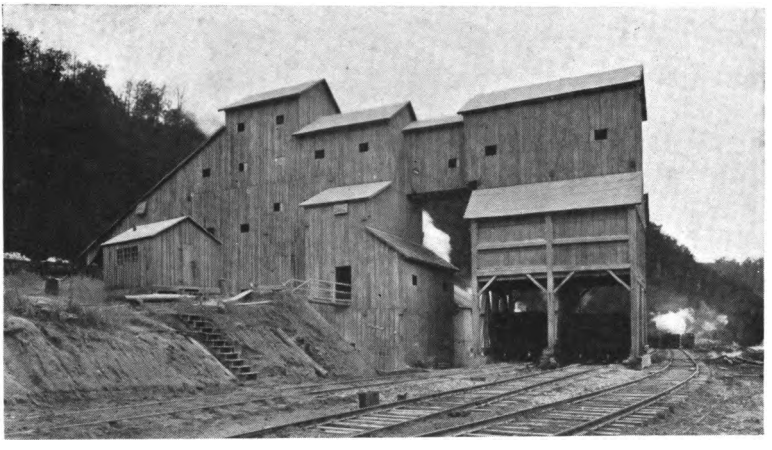


Fig. 1. A crusher plant so arranged that broken stone ballast may be delivered to the cars by gravity, from bins immediately over the track.

been crushed into small-sized fragments, usually by some artificial means. It is generally made from limestone, granite, trap rock, lava, or similar hard rocks. It is reduced to particles of the desired size by means of special crushing machinery, the machinery being operated either by a stationary steam engine and boiler plant, or by a gas engine power plant. The crushing machines are of various types, but in general the principal feature consists of a "mill" having adjustable jaws, making it possible to break the stone into different sizes.

5. The equipment of the crusher plant is generally so arranged that the stone, when crushed, will pass from the crusher into a hopper and then into the first of several

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revolving drum screens, which separate the broken stone into more or less uniformly graded sizes. For instance, the first drum will have holes $\frac{3}{4}$ of an inch in diameter, and after screening the three-quarter inch particles, it delivers its remaining contents into another drum having holes in its surface $1\frac{1}{2}$ inches in diameter. The remaining contents of the drum are then discharged into a drum having holes in its surface $2\frac{1}{2}$ inches in diameter. Any larger particles



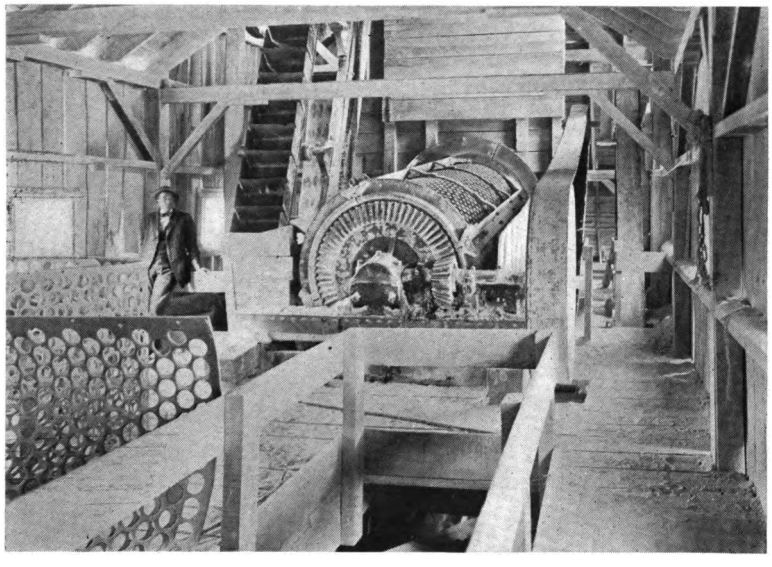
Fig. 2. A gyratory stone crusher.

are returned to the crusher by a conveyor for recrushing. Crusher plants of this type are usually located at some rock ledge or quarry along the railroad track, and at a sufficient elevation above it so that when the broken stone has been discharged from the drums into storage bins, it can be loaded from these bins into cars by gravity. Figs. 1 to 3, inclusive, illustrate several features of a plant of this kind. A type of portable crusher plant is shown in Fig. 4, the complete apparatus being mounted on a flat car.

6. Specifications for broken stone ballast vary, the most recent requirements on some roads being that the largest pieces of stone shall not measure more than 2 or $2\frac{1}{2}$ inches in greatest dimension, and range in size from these

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dimensions down to pieces that measure $\frac{3}{4}$ of an inch in largest dimension. Some roads specify that the larger particles may be 3 inches in greatest dimension, while in some instances screenings in which the largest pieces are $\frac{3}{4}$ of an inch and ranging down to particles $\frac{1}{4}$ of an inch in largest dimension, have been used for ballast, and have given very satisfactory results. The screenings below $\frac{1}{4}$ inch are often used for filling in station walks and platforms. It may be said that the foregoing specifications



ig. 3. Revolving drum screen for grading broken stone into several sizes.

represent the average requirements for broken stone ballast, but some roads vary these to meet their own particular needs or desires.

7. Broken stone should be obtained from hard, sound rock, graded in size so that the bulk of voids (unfilled spaces between the various sized pieces) will be reduced to a minimum, and the material thus made easier to compact solidly in the track. When it is possible to tamp the larger pieces under the ties, it will leave the smaller sizes for use in surfacing, and this will considerably facilitate the latter work.

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8. Although broken stone ballast may in first cost require a larger outlay to meet the expense of ballasting than when some other material is used, nevertheless, broken stone possesses so many desirable qualities as a ballast material that it may be considered the best of those mentioned in the preceding list. It is not so easy to handle in and out of track when making tie renewals, as picks are necessary to loosen it and dig it out of the track, but it can be handled in and out of track in any kind of weather; and if the stone is of good quality, that is, broken from hard, tough rock like limestone, granite or trap rock, it will not crumble or be crushed into dust by traffic or the usual maintenance work.

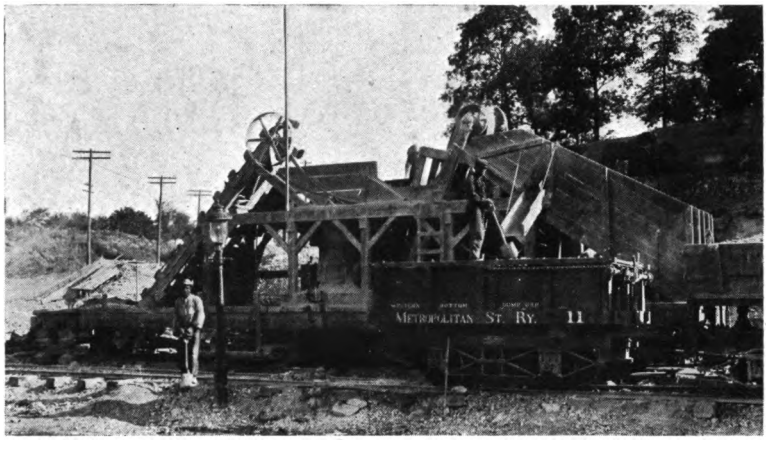


Fig. 4. A portable crusher plant mounted on an ordinary flat car.

9. It should always be handled in and out of track by means of ballast forks, as such handling keeps the material free from loam or earth, or, if the ballast has become forced into the roadbed, it can be separated from the earth by forks and rendered as serviceable as when first placed. Broken stone is one of the cleanest ballast materials, and track so ballasted and properly dressed is practically dustless and presents an exceedingly attractive appearance.

STONE SCREENINGS

10. STONE SCREENINGS also are used for ballast on

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parts of some roads. Stone screenings consist of the particles of broken stone smaller in size than those specified for broken stone ballast, but the specifications usually require that stone screenings be those obtained from hard stone ballast, and must consist of graded sizes, not larger than $\frac{5}{8}$ of an inch in largest dimension and not smaller than $\frac{1}{4}$ of an inch in largest dimension. They must be free from dirt and rubbish.

GRAVEL

11. The term GRAVEL may be considered as applying to quite a variety of ballast materials; that is, it may refer to RIVER GRAVEL, LOOSE PIT GRAVEL, CEMENTING PIT GRAVEL, etc., depending upon the nature of the deposit and the source from which obtained. Gravel is found in large deposits very generally distributed throughout the northern portion of the country. For this reason it is perhaps more generally used than any other ballast material; and notwithstanding the fact that broken stone is a very superior ballast material, a good gravel has many features of merit. A road that has a supply of gravel along its lines, which as taken from the pit is of such a composition that it requires no special preparation for use, is exceedingly fortunate. As a matter of fact, however, many of the gravels used for ballast cannot be placed in the track exactly as dug from the pit. This means that gravels in different sections of the country sometimes contain a considerable quantity of earth, or loam, or contain stones too large in size, or carry too great a percentage of fine sand, or an excess of clay, any of which makes them unsatisfactory for use until they have been screened either to remove objectionable material or to reduce the material to suitably graded sizes, or washed to remove the excess of clay or loam.

12. RIVER GRAVEL, as the name implies, is obtained along river banks, usually above low water. In some cases it is obtained from the beds of rivers by being dredged or pumped up from the bottom. River gravel ordinarily is composed of small rocks mixed with sand, the rocks or

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stones ranging in size from that of a pea to two inches in diameter. Gravel beds in rivers are usually situated where the flow of water is retarded, owing to the river channel being very wide, or where the flow of the river is impeded by islands, bars, or other obstructions. Such deposits are usually rapidly replenished by similar deposits brought down by the waters of the river through its numerous branches.

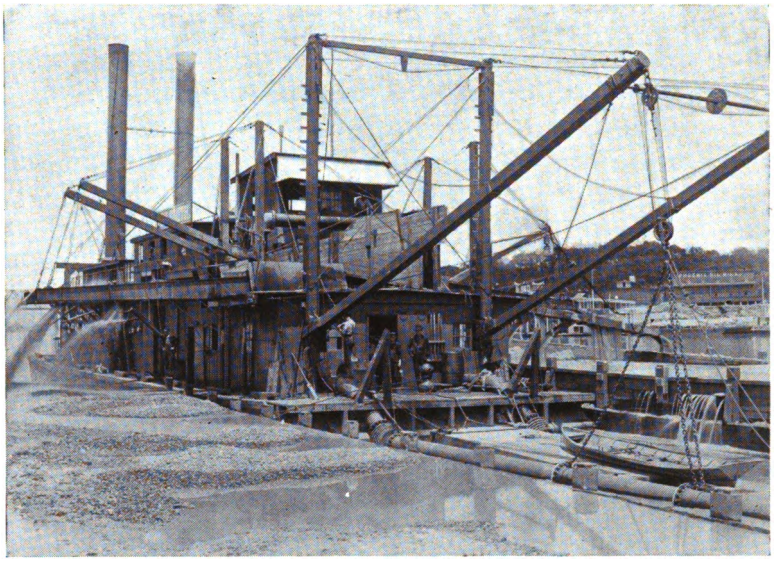


Fig. 5. A suction dredge, by means of which gravel is pumped or drawn up from river bottoms.

13. Where gravel is obtained from river beds, suction pumps or dredges are used to draw it up from the river bottom and deliver it through screens into barges or cars (see Fig. 5). When it is pumped into barges it has to be rehandled by means of clamshell or similar dippers, and loaded into bins or cars. If it is loaded into bins from the barges, the bins are usually so arranged that cars may be run under them and the gravel delivered to the cars by gravity.

14. Most of the gravel known as LOOSE PIT GRAVEL contains an objectionable quantity of sand, although pits

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exist where the deposit is found suitably graded and proportioned to give the ballast a good binding quality. Loose pit gravel is dug out of the pits by means of steam shovels, and if of proper composition, is loaded directly into cars placed to receive it, without being passed through screens.

15. It is probably true that good gravel ballast can be handled in and out of track more economically, and that track so ballasted can be maintained in good condition at less cost, than with any other ballast. If the gravel does not contain more sand than desirable to insure good binding qualities, it provides good drainage, is not heaved to any great extent by frost, and may be easily worked when surfacing track or making tie renewals; neither weeds nor grass will grow in clean gravel, that is, gravel which is free from loam. As a general thing gravel that will all pass through a screen having a $1\frac{1}{2}$ inch mesh may be considered the best. In other respects its value is determined by the proportion of sand and small pebbles ranging downward in size from the foregoing dimension. The percentage of sand in gravel ballast should not exceed an average of from 35% to 40% of its bulk. The sand should be coarse, as fine sand will be washed out of the track by rains, and during dry weather will cause dusty track and increased wear to rolling stock on account of the wear caused by the sand lodging in the journals.

16. The gravel from pits which furnish what is known as CEMENTING PIT GRAVEL is sometimes suitable for use as dug from the pits, but often the quantity of clay is so excessive that if the material is placed in the track without washing, the ballast will not provide proper drainage. Therefore many cementing gravels have to be washed before they can be made suitable for ballast.

17. Various forms of washer plants have been constructed to treat gravel containing a surplus of clay. In some cases the gravel to be washed is loaded into bottom-dump cars from which it is discharged into a hopper and then delivered to a belt conveyor passing through a chute

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where it is washed by jets of water. Pieces over a certain dimension are screened out and delivered to a crusher to be reduced to suitable sizes. After passing over other screens which grade the gravel in the same manner as broken stone is graded, the material is discharged into a bin from which it can be loaded into cars by gravity.

18. In other washing plants the gravel is made to pass over screens or tables against which streams of water are kept playing, to wash out objectionable material. It has been found that the labor expended to wash gravel and thereby make it more suitable for use is generally well spent. Many gravel banks which contain gravel mixed with too much clay, and, therefore, in the natural state unsuitable for ballast, have been made available by the installation of suitable washing plants at the pits.

SLAG

19. SLAG is the waste product, or residue (usually the product of a blast furnace), obtained by smelting various kinds of ores. Slag from furnaces smelting pig iron is probably the best for making ballast. When broken up and graded to approximate the standard specifications of broken stone, it makes a ballast material that is second only to the best grade of broken stone. To render it suitable for use as ballast the slag is broken up by blasting, and further reduced to suitable size by crushing if necessary, in a manner similar to that described for broken stone.

20. Almost all slag as it comes from the smelters contains confined chemical gases which some claim affect the rails by causing corrosion in a greater or less degree. The contention is that it is best to break up slag which is to be used for ballast, and to allow it to lie exposed to the atmosphere a while so these chemical gases may escape, as they will in time, before putting the ballast in the track. The general opinion, however, is that the foregoing claim regarding injury to rails is not supported by the facts.

21. The supply of slag is naturally limited to those

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sections of the country where smelting operations are being carried on. Therefore this material cannot be conveniently or economically obtained or used except within reasonable hauling distance of such localities. Many roads whose lines pass through the smelting regions where iron ores are treated, use large quantities of slag ballast. In such cases the ballast is a cheap one. Otherwise its use is not general. It provides good drainage, prevents the growth of weeds in the track, and is free from dust, possessing in general the desirable qualities of broken stone. Slag should always be handled in and out of track by using ballast forks.

CINDERS

22. CINDERS is a residue from coal which has been burned in locomotives or other furnaces. On railroads the material is obtained principally from roundhouses along the railroad where engine fires are cleaned and drawn. Engine fires are cleaned into cinder pits, and the cinders later loaded into cars and hauled where needed for use as ballast.

23. Cinders makes a good ballast for certain classes of track, and is especially valuable for ballasting branch lines having light traffic. Being considered by most roads in the nature of a refuse material which must be disposed of in some way, it is a cheap ballast material when placed in the track, but it is not to be recommended as a ballast for main lines. Being porous in nature, it provides fair drainage for track, although when first placed it is likely to be somewhat dusty on account of the free ash in the cinders. This will wash out after several rains, however, and thus remove this objection. Aside from being used as ballast on some branch lines, cinders are used to fill in mud holes or wet spots. There is considerable difference of opinion among maintenance of way officials as to the merits of using cinders to fill in wet spots as mentioned. Some contend that the practice results in the formation of "pockets" in the roadbed, that collect and retain water. Also, there undoubtedly is an objection

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to the use of cinders on main line track since chemical gases contained in the cinders often cause "pitting" or corrosion (eating away) of the rails and fittings. One advantage of cinders ballast is that it does not encourage the growth of weeds and grass.

SAND

24. SAND is a hard, granular, finely divided, rock-like material, finer than gravel and coarser than dust. It is inferior to any of the ballast materials already mentioned. It is widely distributed, and is extensively used only because many roads are of necessity forced to use it, owing to the absence of any other available ballast material. In fact, it is the only available ballast material throughout an extensive section of the country.

25. The distinction between gravel and sand is not closely drawn. What would be called gravel in a sand country might be called sand in a gravel country. The average sand holds moisture and washes easily. It makes a fairly good ballast under light traffic conditions, but when dry it is difficult to hold in place, and in sections of the country where bad wind storms are frequent, all of the sand may be blown out of the track in a short time; therefore it is not a reliable ballast material. Most sand contains considerable loam or is made up of very small, light grains, and consequently sand ballasted track is very dusty, causes considerable discomfort to passengers, and injury to rolling stock. Nevertheless, not all roads can obtain dustless ballast nor can they entirely prevent some of the dust due to traffic. Some roads have followed the practice of sprinkling sand ballasted track with a light application of crude oil which, when properly applied, does away with most of the dust. The oil is applied from a special car equipped with spraying or sprinkling pipes in a manner similar to the watering carts used for ordinary street sprinkling. The pipes are arranged so that they can be adjusted to sprinkle a strip of varying width, ranging from 14 to 20 feet or more. This treatment also pre-

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vents considerable of the washing during rains, and, if properly done, is effective in suppressing a growth of weeds.

DECOMPOSED GRANITE

26. DECOMPOSED or DISINTEGRATED GRANITE is used quite extensively on some western roads as a ballast material. It resembles clean gravel except that the particles are rather angular in form instead of rounded. As used on one large railway system of the west, this material is known as Sherman Gravel, owing to the fact that it is obtained in the vicinity of Sherman, Wyoming.

27. Decomposed granite is found in abundance at various other points through the Rocky Mountain region. It is removed from the beds by blasting, which breaks the material up into small cubes about the size of a pea. After being blasted, the material is loaded on cars by means of steam shovels. It forms an almost ideal material for ballast, is practically dustless and provides good drainage.

BURNT CLAY

28. In certain sections of the country BURNT CLAY is used as ballast, mainly in the West. Some form of brick clay is regarded as most suitable, but any clay which does not carry an excess of sand, also the so-called gumbo soils, may be used to manufacture burnt clay ballast.

29. The burning process employed in preparing this form of ballast is somewhat as follows: Long stretches of ground adjacent to the track are cleared of rubbish, and a layer of old ties or cordwood spread upon the ground. On top of this is placed a layer of fine coal, or "slack," and on top of the coal a layer of the clay which is to be burned. Consecutive layers of wood, coal and clay are added until piles four or five feet in height have been made. Then the piles are fired. When completely burned, the clay will have been partly fused, so that it somewhat resembles slag. It is then broken up to suitable size, and is referred to as burnt clay ballast. Such material makes a good ballast for branch lines, and for main lines where

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traffic is not heavy, but the material is one the use of which is confined, as already mentioned, to somewhat limited sections of the country.

CHATS

30. CHATS is a species of ballast peculiar to sections of southwestern Missouri and portions of Kansas, and when first used was obtained from the refuse piles of mines treating the zinc or lead ores mined in these localities. Under the early processes of operating these mills, the material was obtained in large lumps, similar to the sizes of broken stone ballast, but variations in the methods of treating the ores have resulted in a changed product which now resembles coarse sand, containing particles from $\frac{1}{4}$ inch in size down to about the size of grains of wheat. It forms a very compact ballast, being heavy, easy to work and free from dust, but its use is more or less confined to the sections mentioned.

CHERT

31. CHERT is a form of finely disintegrated stone. Its use is confined mainly to limited sections of the South, in ballasting branch lines. Owing to its containing varying proportions of clay, it somewhat resembles the cementing gravels.

OYSTER SHELLS

32. OYSTER SHELLS are used to a limited extent for ballast in the region of Chesapeake Bay, where large quantities may be obtained at nominal cost. Shells do not form, however, a desirable ballast, for although they make at first a dustless track, the material is too light for the best results. The crushing and grinding of the shells, due to ordinary track maintenance, soon causes soil to become mixed with them, which encourages the growth of vegetation.

DIRT, OR EARTH

33. Where track is ballasted with the ordinary soils found along the right of way, the ballast is usually referred

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to as DIRT, CLAY, EARTH or "MUD." In some sections of the country such materials have been the only available ones for ballasting, although most roads are making the effort to replace such ballast with gravel, broken stone or slag, where it is possible to obtain any one of these materials at not too great an expense.

34. There are many objections to ballasting track with the ordinary soils found along the right of way. Ordinary dirt or earth contains a large percentage of loam, and it is practically impossible to keep track so ballasted free from vegetation. Dirt ballast also makes very dusty track. It washes badly during rains, and when it consists largely of clay, forms a very unstable support to the track during protracted rainy spells, as the clay becomes somewhat fluid in nature, and is forced from under the ties by the weight of traffic. These objections make it very difficult to maintain track so ballasted. If the natural soil used contains a large quantity of sand, it will bake badly after a rain followed by hot weather, causing the material to become so compacted as not to provide suitable drainage to the track. Track ballasted with natural soil is also especially subject to bad heaving during freezing weather.

MISCELLANEOUS

35. Some other materials are used to a very limited extent for ballast, but not sufficiently to need consideration in this lesson.

BALLAST CROSS SECTIONS

36. Various ballast cross sections are employed, depending upon whether the road is to be single or double track, and upon the firmness and stability of the roadbed, the climatic conditions of the particular territory under consideration, the kind of ballast to be used, and the traffic of the road. The average width of roadbed varies from 16 feet to 20 feet for single track, and from 26 to 33 feet for double track, the variations being governed by height of embankments, location through cuts, etc. In roadbed

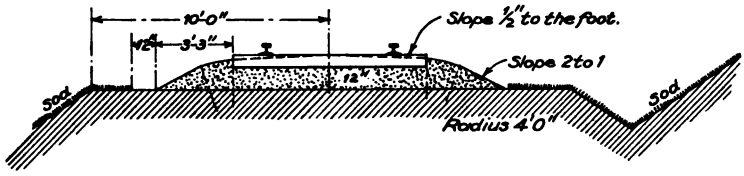
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construction it is generally considered good practice either to crown the top of the roadbed by forming a slightly curved surface, or by giving it a gentle slope with one or more planes in both directions from a center line. This is to allow for any settlement of the roadbed and to provide a foundation for the ballast that will insure good drainage. This crowning does not last long, however, owing to the gradual settling of the roadbed, but constructing the roadbed in this manner will usually prevent the top surface from becoming concave through settlement.

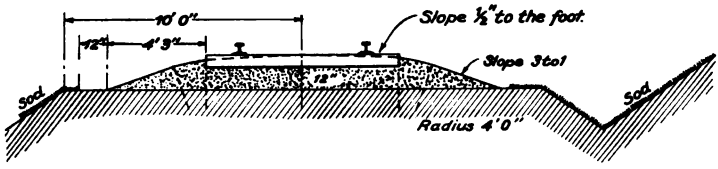
37. Various ballast cross sections recommended by the American Railway Engineering Association and standard on some large railroads are illustrated in Figs. 6 and 7. The first shows cross sections for single track and the second for double track. The sections for Class A single track are one half the double track sections with shoulder as shown. The cross sections illustrated are subject to considerable variation on roads where unusual local climatic conditions must be met, although the tendency is now to approach a practically uniform cross section for all similar materials. The standards of each particular road exist because they seem to best meet local conditions, and trackmen should be guided by the instructions of their Engineering or Maintenance of Way Department.

38. The depth of the ballast should be regarded as extending from the bottom of the ties to the top of the roadbed. On curves, the depth of ballast should be measured under the inner rail of the curve and increased under the outer rail to give the necessary elevation. The depth used may vary to a considerable extent, depending upon the firmness and stability of the roadbed, the climatic conditions, the nature of the traffic, and the kind of ballast. Only within recent years has it been approximately known what amount of ballast was necessary under the ties to produce an absolutely uniform pressure on the subgrade. Twelve inches under the ties is better than a lesser depth; nevertheless, on account of the outlay required, this depth is not the actual standard on many roads.

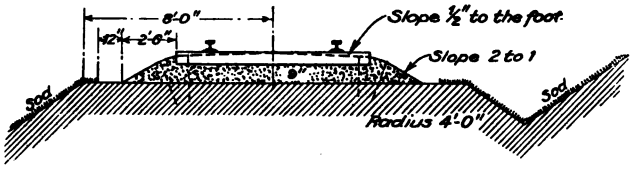
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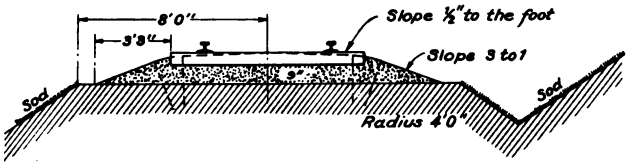
Gravel, Cinders and Chats—Class A Track



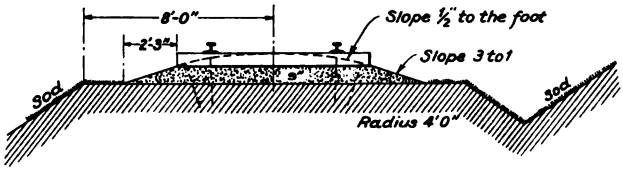
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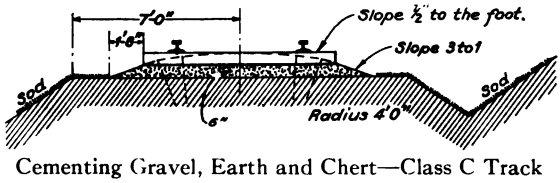
Crushed Stone and Slag—Class B Track



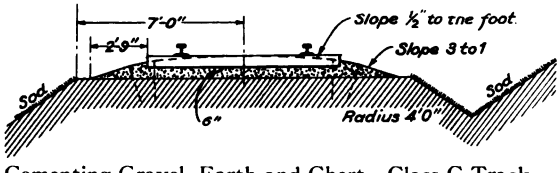
Gravel, Cinders and Chats—Class B Track



Gravel, Cinders and Chats—Class B Track



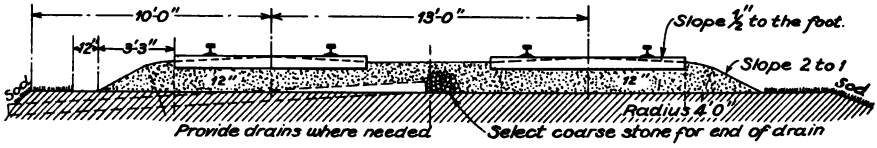
Cementing Gravel, Earth and Chert—Class C Track



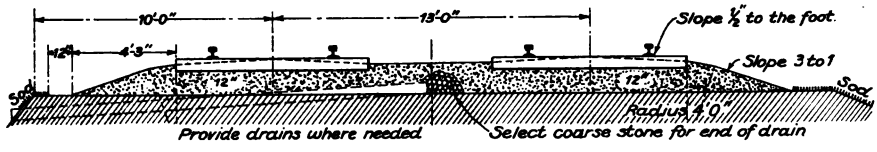
Cementing Gravel, Earth and Chert—Class C Track

FIG. 6. SINGLE TRACK, BALLAST CROSS SECTIONS.

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Crushed Stone and Slag—Class A Track



Gravel, Cinders and Chats—Class A Track

FIG. 7. DOUBLE TRACK, BALLAST CROSS SECTIONS
(One half of either of these sections with shoulder formed as shown, is the ballast section for the materials mentioned, on Class A single track.)

39. Probably the greater portion of the railroad track in this country is ballasted with from six to eight inches of ballast under the ties. On many roads eight inches is considered standard. Really first class track should have not less than twelve inches. This is the standard of the Illinois Central Railroad, for instance, although the Pennsylvania Railroad considers thirteen inches necessary on first class track, and in at least one case a standard of fourteen inches is maintained, by placing eight inches of broken stone on six inches of gravel. It may be stated without fear of contradiction that the depth of ballast on first class track on main lines should be at least eight inches.

40. The amount of ballast required per mile of track depends upon a number of conditions, such as, whether single or double track, the size and spacing of ties, and the road's standard requirements as to ballast materials, cross sections and depth. Table No. 1 shows approximately the number of cubic yards per mile under several conditions, and will be useful for reference in arriving at an approximation:

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TABLE NO. 1

	Width of Roadbed		Ballast	
	Cuts	Banks	Width Over Toe	Quantity per Mile. Cu. Yards
Single Track.....	19 ft. 8½ in.	19 ft. 8½ in.	13 ft. 8½ in.	2,629
Double Track.....	36 ft. 8½ in.	32 ft. 8½ in.	27 ft. 0½ in.	5,127

The foregoing is based on a minimum depth of 6 inches below ties at the middle, increasing to 12 inches under the ends, the ballast being level with the tops of ties and shouldered from their ends. Such practice is not common, however, as the crowning of the roadbed would be extreme. Table No. 2 gives an approximation of the amounts required in cubic yards per mile, when the depth is uniform.

TABLE NO. 2

Depth of Ballast Under Ties .	12 in.	10 in.	8 in.	6 in.
Stone, Gravel, Burnt Clay (cubic yards per mile)..	3,400	2,880	2,410	1,940
Cementing Gravel (cubic yards per mile).....	3,470	2,930	2,560	2,180

These figures are susceptible to the variations consequent upon the spacing, length and thickness of ties, and the amount of shoulder provided.

41. Not only must ballast be dressed to proper cross section, but these cross sections must be maintained when doing the usual maintenance work. The proper shoulder should be provided, and a suitable slope made from the point of the shoulder to the toe of the track, where the ballast should be formed to a neat, true line.

42. By referring to Figs. 6 and 7, it will be seen that the cross sections shown for broken stone, loose gravel, slag, and cinders, provide for a full shoulder of ballast at the

NOTE: A Booklet of Ballast Charts and Tie Tables, showing quantities of Ballast, in cubic yards per mile, etc., is issued by the Rodger Ballast Car Co., Chicago, Ill. Copies can be obtained from the above company by referring to this lesson text, or will be furnished by the Bureau if not otherwise obtainable.

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ends of the ties; and that where ordinary earth and cementing gravel are used the cross sections show less shoulder than is used with broken stone, slag, etc. As a rule, less shoulder need be provided for track ballasted with cementing gravel than when ballasted with lighter material. It will be found difficult to hold track in line without some shoulder at the ends of ties, and track on curves should generally be provided with a full shoulder to withstand the lateral (side) thrust of trains.

43. On some roads, broken stone ballast is placed level with the tops of the ties, then extended or shouldered from 6 to 12 inches beyond their ends to hold the track in line. On other roads, the practice is to round off the shoulder from the ends of the ties. The first-mentioned practice, although requiring more ballast, is the better. It not only makes neater looking track but holds the track in better line, especially on curves. The shoulder is generally made to slope $1\frac{1}{2}$ to 1 or 2 to 1; although, as will be seen by reference to Figs. 6 and 7, the American Railway Engineering Association recommends a slope of 3 to 1 in some cases.

44. Through suburban districts, where it is desired that track present an especially attractive appearance, it is sometimes customary to "hand face" the slopes, the toe line being formed by placing the larger pieces of ballast true to a line. This method, however, is expensive and seldom compensates for the effort expended. A less expensive and equally satisfactory way is to use a marker or line to mark the toe of the slope, and then to handle the ballast into place with ballast forks.

45. Cross sections for loose gravels may be considered as closely conforming to the sections for broken stone, although, as already mentioned, there is considerable variation of practice among different roads. Sometimes gravel ballast is placed level with the tops of the ties and shouldered out from 6 to 12 inches beyond their ends, and again is placed level with the tops of the ties for a distance of

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3 feet and then sloped until it is from 2 to 3 inches from the tops of the ties at their ends. The latter method is desirable when consideration must be given to quick drainage of water where much freezing and consequent heaving have to be anticipated.

46. The cementing gravels are usually dressed so as to slope from the tops of ties at their center and to the bottom of ties at their ends, from which point the usual slope to the roadbed is 3 to 1. Sloping the ballast from a point some distance inside the rails leaves a free space below the rail flange, and prevents the accumulation of water between the rails of the track. These sections are generally modified in locations where much hot, dry weather prevails, a common custom then being to leave more or less covering of ballast on the ties between the rails, particularly for the purpose of preventing fire from dropping coals.

47. Cross sections for slag, burnt clay, cinders, sand, and ordinary dirt or "mud" ballast vary in general as do the cross sections described for broken stone and gravel. It may be said that as a rule the most suitable cross sections for slag correspond to those for broken stone; the cross section for burnt clay also corresponds to that for stone, but as burnt clay is a light material, the shoulder should be well formed 12 inches beyond the ends of the ties, and the ballast used in liberal quantities underneath them —not less than 12 inches. The section for sand should correspond to that for gravel; that for ordinary earth ballast should be carried up to from 1 to 4 inches above the ties in the center of track, and from there form a sharp slope to their bottom at the ends, leaving a clear space under rail flanges so as not to hold water between the rails. (Sometimes sand is finished to cross section the same as ordinary earth.) It is particularly important that the roadbed on which ordinary earth ballast is to be used shall be firmly compacted to thus assist in giving better drainage to the track.

PREPARING TO DISTRIBUTE BALLAST

48. Ballasting of track is performed under several

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conditions, such as when constructing new line, and in connection with maintenance work requiring a general raising of track, or a general improvement in the surfacing making reballasting necessary. Under the first condition a practically uniform quantity of material will be required throughout, while under the second condition the quantities necessary will vary. In connection with the construction of new line it is common to place only half, or a little more than half, the standard depth of ballast under the ties at first, the additional amount necessary to complete the standard cross section being added when the ballast first deposited has become thoroughly compacted. Ballast should not be distributed until fills have been completed and the roadbed formed to proper section and thoroughly compacted.

49. Grade stakes are then set by the engineering forces to indicate the proper level for the top of the rail. Such stakes are sometimes set on both sides of the track 5 feet from the center line. In other cases a row of stakes set 4 feet from one rail of the track is the practice. The stakes should be far enough from the track so they will not be disturbed by whatever unloading and spreading equipment is used, and should be placed at intervals of not less than 100 feet on tangents (straight track) and at more frequent intervals where changes of grade occur. On curves the stakes should be set every 50 feet and should show the proper elevation for the curve.

50. Before any ballast is distributed to new track, the skeleton track should be roughly lined up and inequalities of surface corrected so that the weight of the ballast train will not bend or kink rails, which is very likely to happen if these precautions are not taken. Joint connections will also be injured if inequalities of surface are not given attention. Fig. 8 shows a section of skeleton track being partially lined to permit the passage of the ballast train. Fig. 8 (*a*) shows a stretch of new parallel track that has been lined preparatory to placing ballast although, as will be seen, there remain some ties to be placed in the track.

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METHODS OF DISTRIBUTING

51. There are various types of cars used to distribute ballast. Some of these are constructed so that they can

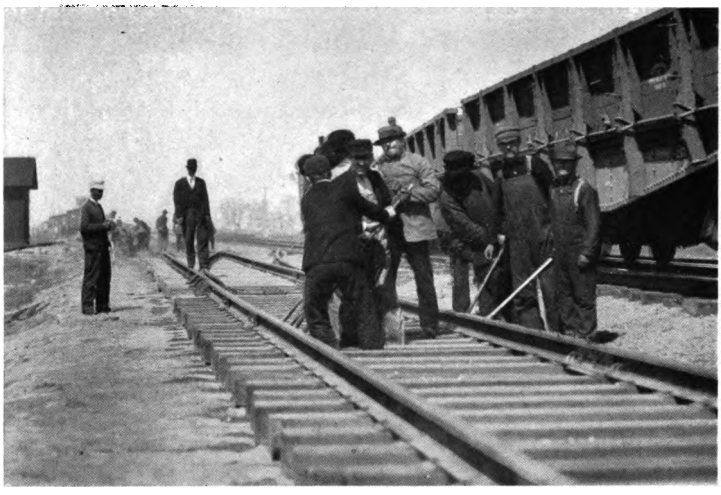


Fig. 8. A section of new track being roughly lined to permit passage of the ballast train.



Fig. 8 (*a*). To the right is shown a stretch of new parallel track, that has been placed in fair line and surface, preparatory to the distribution of ballast.

be readily converted to unload either from the side or center, as may be desired. Representative types of ballast cars include the Rodger Ballast Car, the Hart Convertible

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Car, the Haskel and Barker Car and the Goodwin Car. See Figs. 9 to 18, inclusive. The idea that is being followed in the construction of all modern ballast cars is to so design such cars that when not in use for the purpose for which they were particularly designed, they can readily be arranged to handle different kinds of commercial freight,



Fig. 9. The Hart Convertible Car, which can be used for side unloading or center dumping.

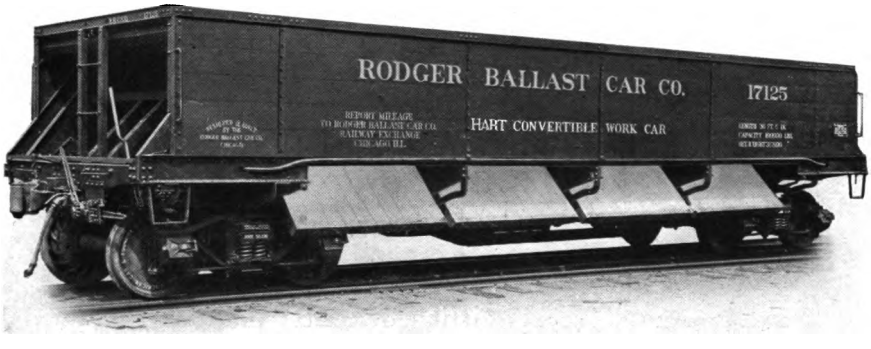


Fig. 10. The Hart Convertible Work Car having both side-dump and center-dump features.

so that the railroad will not have to tie up cars that have such exclusive features as not to make them suitable for general traffic requirements.

52. The Rodger Ballast Car Company now manufactures both the Rodger Ballast Cars and Hart Convertible Cars. Fig. 9 shows one type of car manufactured by this company known as the Hart Convertible Car. The figure shows the side doors closed so that if necessary the car can be used not only for transporting ballast but for

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other road service. Fig. 10 shows the side dumping arrangement of another type of car open as when discharging ballast. Both of these types of cars can be converted into center-dump cars by raising false flooring above the center hoppers. Cars of these two types are made from 32 to 34 feet in length, and to have any reasonable capacity, up to 50 cubic yards.

53. Fig. 11 shows what is known as the Hart Convertible Ballast Car. As illustrated this car has had the ends removed to provide for drawing an unloading plow from car to car for side unloading, which is arranged for in the car mentioned. This car also has hopper doors

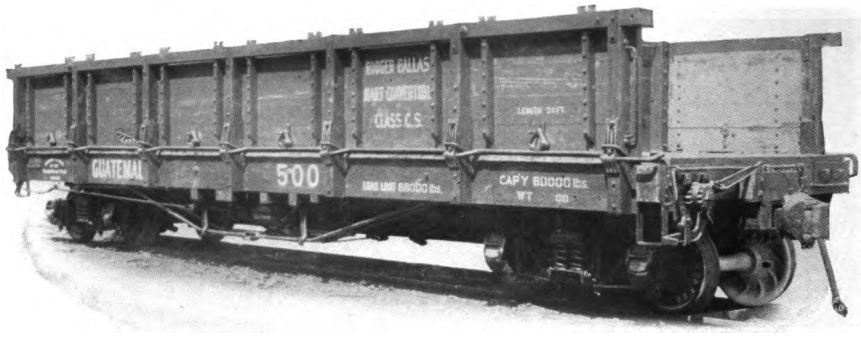


Fig. 11. The Hart Convertible Ballast Car, arranged for side unloading by plowing ballast from the car. This car can be used for center-dumping also.

in the bottom, thus permitting of center dumping. Fig. 12 shows the center-dump arrangement of the cars in Figs. 9, 10 and 11, illustrating how the floor of the car may be removed by opening the doors that form the floor and turning them back against the car sides, providing for use of the center-dump features. The sectional views represented by Figs. 13 and 14 give an idea as to the manner in which the placing of ballast can be controlled both in side and center-dump cars.

54. The Haskel and Barker Car shown in Figs. 15 and 16 is similar to the cars shown in Figs. 9 and 10, the difference being that the car is not of a convertible type, and is intended for use only in side unloading.

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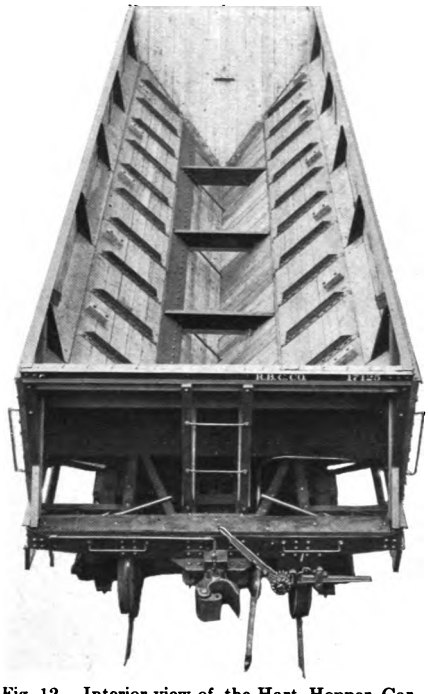


Fig. 12. Interior view of the Hart Hopper Car, as arranged for center dumping. This is another view of the car shown in Fig. 10.

55. Fig. 17 illustrates what is known as the Goodwin Car. The discharge of contents from this car is controlled and regulated by apparatus using compressed air. The sectional views shown in Fig. 18 are of the Goodwin Car and illustrate how, by varying the positions of side doors or bottom hoppers, or combining the use of both, the flow of ballast may be regulated and directed to almost any desired position on the track.

56. Ordinary flat cars are sometimes used for distributing ballast, although most roads now own and operate ballast cars of one or more of the several side, center-dump or convertible types. (The ordinary flat car has a capacity of from 10 to 12 cubic yards.)

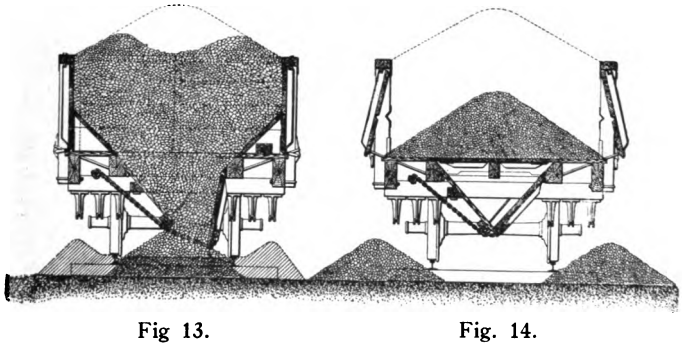


Fig 13. Fig. 14.

57. Nearly all of the gravels, except cementing gravels and those containing a considerable percentage of coarse, flinty sand, are distributed to new track from some

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form of center-dump car. Broken stone, decomposed granite, some gravels, mine tailings, cinders, and usually slag and burnt clay, are distributed to track by cars of this type. Cementing gravels compact to such a degree when being hauled that they cannot be satisfactorily



Fig. 15. The Haskel and Barker Car for side unloading only.

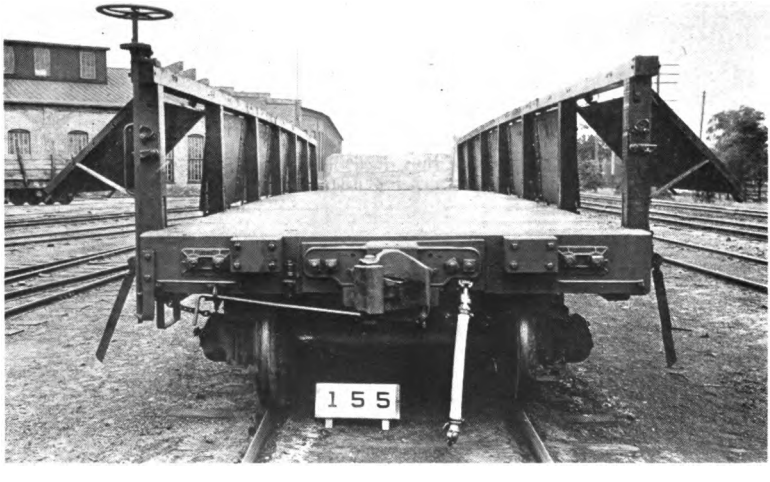


Fig. 16. Another view of the car shown in Fig. 15, illustrating how the sides open to discharge contents when plowing off the ballast.

handled in center-dump cars. Ballast is usually hauled to the point where it is to be distributed in trains of from 30 to 50 cars. This number of cars, however, cannot usually be handled at one time by the work engine. In unloading, from six to twenty cars, depending upon the class of engine, are usually handled.

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58. Enough ballast should be unloaded before any raising is done to complete the raise required or specified. In some cases, enough is unloaded before attempting to raise track, to finish ballasting to the standard section. When this practice is followed, sufficient judgment should be exercised so that it will not be necessary to go over the track after raising has been accomplished, to spread any more ballast with which to finish. Experience will furnish a guide as to the number of runs to be made before raising is begun. Ordinarily three full runs with center-dump



Fig. 17. The Goodwin Car. This car has combined side and center-dump features, which are under such control as to permit wide range in unloading, as shown in Fig. 18.

ballast cars will be sufficient to complete track to standard section for a 9-inch raise, and as a rule, there will be very little, if any, extra moving of ballast required by push car or otherwise. Special care must be taken not to unload on the final run, a surplus over what is needed to fill in and dress track.

59. It requires considerable experience and good judgment to get an even distribution of ballast from center-dump cars. The distribution is governed by the speed with which the ballast train is moved and the extent to

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which the hoppers on the cars are opened. It should be remembered that bottom-dump, or hopper, cars are so arranged that the hoppers may be opened to varying widths, ranging up to 20 or 22 inches, and with proper management of the train the rate of discharge can be kept within reasonable control. But it must be borne in mind that the opening cannot be *reduced* while the ballast is flowing through the hoppers, and if they are opened to a distance that will permit a too rapid discharge of the contents, it is quite likely that more ballast than is required will be discharged on the track. In fact, it is quite necessary to use precaution to so control the discharge that an excess sufficient to stop or stall the train will not be placed on the track.

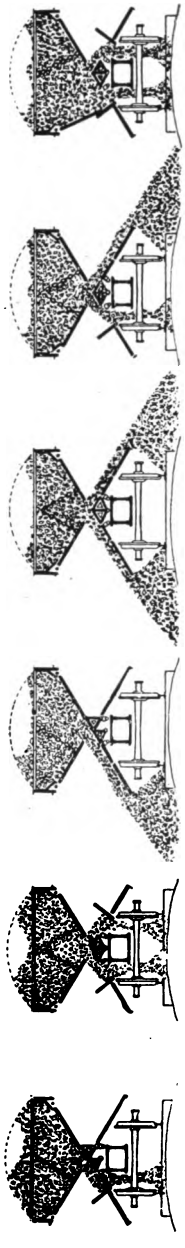


Fig. 18. Cars discharging, with ballasting bolts and chains set to restrict the flow of the material. (The Goodwin Ballast Car)

60. In one method of unloading ballast from center-dump cars the engine is placed at the rear end of the train to be unloaded, with a ballast plow, or spreader, such as illustrated in Fig. 19, between the engine and the rear car. The train to be unloaded is pushed by the engine, and the unloading is usually done by opening the car farthest from the engine, sufficiently so that while the train is slowly moving forward (at a rate of from 3 to 6 miles per hour), only enough gravel will be discharged to fill the center of the track to the top of the rails after being spread by the plow. When the ballast in the first car is about two-thirds unloaded, the next car is opened and discharged in the same manner; and so on to the

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end of the train. By the time the last car has been unloaded the plow has the ballast plowed off the track, level with the top of the rails. Sometimes unloading from center-dump cars is begun from the car next to the engine, and continued throughout the train before spreading.

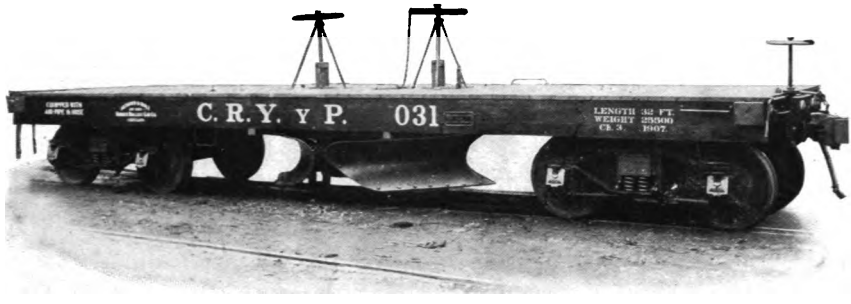


Fig. 19. The Rodger Ballast Plow, or Spreader.



Fig. 20. The Rodger Ballast Plow, or Spreader, in operation.

61. The Rodger Ballast Plow, or spreader, illustrated in operation in Fig. 20, is mounted on an ordinary type of flat car, so arranged that the plow can be lowered to the tops of the rails when spreading, and raised from them when not in use, by means of a worm screw operated from the car platform (see Fig. 19). Plow cars of this kind are made either with one or two plows, which in the latter case are placed as shown in the illustration. This arrangement is decidedly convenient since it does away with the necessity for turning the car, it being necessary only to raise whichever plow is not required, depending upon

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the direction in which the car is being operated. The wings of the plow are sometimes notched immediately over the rails so that the plow can be dropped slightly below the level of the rails, to also act as a flanger to clear the ballast away from each side of the rails, and so prevent the possibility of derailment of trains which must pass during the progress of ballasting. Sometimes the wings of the plow are built out so that ballast can be spread 6 inches or more outside the rails.

62. Side-dump cars are necessary for some materials



Fig. 21. The Lidgerwood Unloader unloading from ordinary flat cars.

which can not be easily unloaded from center-dump cars. The various types of side-dump cars are now almost universally unloaded by operating a plow, which is pulled from car to car throughout the length of the train by means of a cable extending from the nose of the plow to the drum on a form of hoisting engine working, however, with a horizontal pull and mounted on a flat car at the opposite end of the train.

63. The most common unloader of this type is known as the Lidgerwood Unloader which is shown in the Frontispiece of this lesson, also in Fig. 21. The engine usually receives its steam from the locomotive through a "goose

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neck" or flexible steam-pipe coupling. The gaps between cars to be unloaded in this manner are bridged over by steel aprons that are so hinged to one end of each car that, when dropped in position, they rest on the next car and bridge over the draw bars and space between cars, so making a continuous floor from car to car. In this arrangement it is of course necessary that hand-brake wheels be mounted at the sides of cars. Figs. 22 to 24, inclusive, show the Lidgerwood Unloader being employed under various conditions. By referring to Fig. 22 it will be



Fig. 22. The Lidgerwood Unloader operating on a trestle to make a fill.

seen how, by operating the plow in one direction and moving the train at an equal speed in the opposite direction, all of the material being discharged from the train on the trestle may be deposited in one place if desired. On the other hand, Figs. 21, 23 and 24 show the unloader being operated under usual conditions of usage, it being possible, if necessary, to handle very heavy boulders in unloading, as shown in Fig. 24. The train can be unloaded while standing, or, if necessary, while moving, so as to secure the desired distribution of ballast. Side-dump cars may also be unloaded by pulling the plow with the locomotive, after setting the brakes of the train, uncoupling the loco-

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motive, and moving it forward. This method, however, is not so satisfactory as operating the plow by means of a Lidgerwood Unloader, since all of the ballast must be unloaded where the train is standing, and this is not always desirable. When using a Lidgerwood Unloader to distribute ballast on a curve, it is necessary to guide the cable from the plow to the engine drum by means of pulley blocks attached to lugs fastened to the sides of the cars on



Fig. 23. The Lidgerwood Unloader operating to unload a train on a curve, contents of cars all being thrown to one side. Stakes are set on ordinary flat cars as shown, to prevent the plow from running off the cars.

the outside of the curve, so that the cable will follow the center line of cars and the plow will be drawn straight, and thus discharge equally from both sides of the cars. This is shown in Fig. 23. Sometimes limited quantities of ballast are handled on ordinary flat cars, and if the unloading is to be done by plowing, short stakes are placed on the sides of the cars so that the plow will not slip off on either side while being drawn from car to car. This also is shown in Fig. 23.

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64. Figs. 25 and 26 illustrate two devices which are employed for stretching the cable from the unloader engine to the plow at the opposite end of the train, preparatory to unloading. Of course, the arrangement on the car shown in Fig. 25 can not always be used out on the road, since double track or a siding is necessary for the employment of this method of stretching the cable. The method shown in Fig. 26 can be adapted to any usual conditions. It consists of erecting a stout pole on each



Fig. 24. The Lidgerwood Unloader plowing off heavy boulders.

side of the track so that the poles are opposite each other, and stretching a short piece of cable across the track from pole to pole. One end of the plow cable is then attached to the cable suspended on the poles and by moving the train the plow cable is dragged to the other end of the train for attachment to the plow.

65. Hand unloading is more expensive than any of the methods above described, and unless the quantities to be unloaded are small, and the places where necessary to unload some distance apart, hand unloading should never be practiced. In unloading ballast for ordinary

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maintenance work a much smaller quantity is handled at each place than is required for construction work or a general raise of track, and whatever the method of unloading employed, care should be taken to unload no more than is needed at each place so that unnecessary handling of surplus ballast will be avoided; also to take precautions against spilling or wasting down embankments.

66. Ballast unloaded from center-dump cars is sometimes spread by means of a dapped timber or old tie placed ahead of the rear wheels of the last car in the train. The

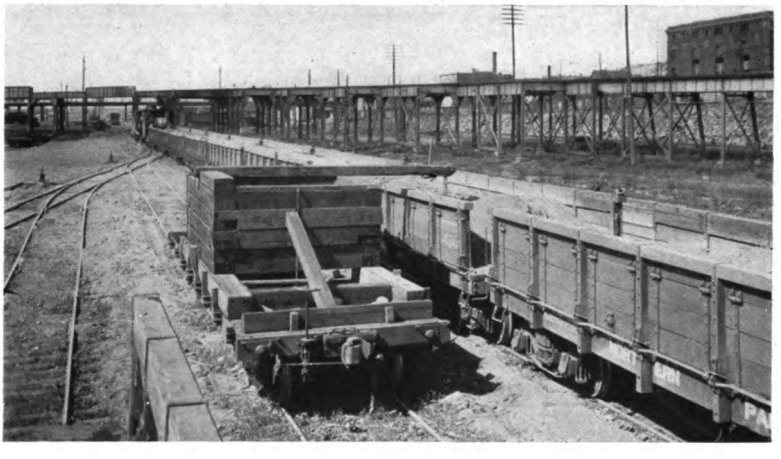


Fig. 25. Car used to stretch the cable from the unloader to the plow.

equipment shown in Fig. 27 consists of a piece of timber 7 by 9 inches by 8 feet, covered on the bottom with sheet iron and dapped two inches where it is to lie on the rails, enough ties being piled on top to build up to the draw head of the car used as a spreader. By dapping the timber, which means notching it to a depth of about 2 inches on the lower side so that it will fit down over the rails, very little ballast is left above the rails after spreading. Skid shoes should be attached to this timber where dapped for the first pair of wheels to rest upon so that they will not be flattened. A common 6-hole angle bar, securely bolted or spiked to the timber, so that one "leg" of the angle iron extends downward alongside of the rail, between the two

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rails of the track, makes a serviceable shoe that also does some flanging along the rails. The foregoing methods for spreading apply to any of the kinds of ballast which can be unloaded from center-dump cars. Figs. 28 and 28 (*a*) show broken stone unloaded, and the appearance after spreading. Fig. 29 shows Sherman gravel (disintegrated granite) after spreading with the Rodger Ballast Plow.

67. When ballast is distributed from side-dump cars, naturally there is much shoveling to be done to get the

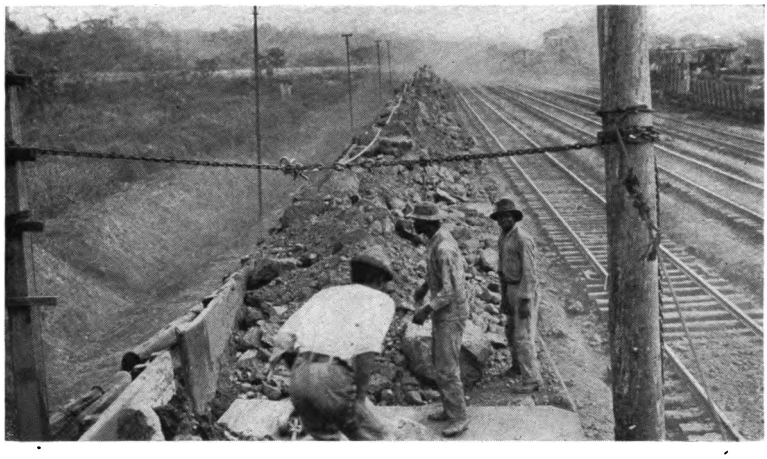


Fig. 26. Plow cable attached to short cable stretched across the track so as to haul the unloading cable from unloader to plow.

ballast into the center of the track, but many roads prefer side-dump cars; furthermore, such cars must often be used because many varieties of ballast cannot be discharged or cannot be distributed evenly from center-dump cars. Ballast should never be loaded in solid coal cars if it is at all possible to avoid so handling it, because of the unreasonable labor and expense involved in such method.

68. Various devices have been improvised for spreading ballast practically where needed for new parallel tracks after it has been deposited at the side of the old track from side-dump cars. One type of spreader car, used at the rear of the train, is equipped with an adjustable wing

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hinged to the base of the car and extending beyond it so that it can be made to operate at a distance of from 15 to 20 feet at one or both sides. (See Fig. 30.) Cars equipped in this manner are usually flat cars having a hanging frame or side posts from which stays are fixed to the outer end of the spreader, this being usually a long plank placed at an angle of 45 degrees with the spreader car and faced with iron. Adjustments are provided so that the spreader can be raised and lowered as desired; and

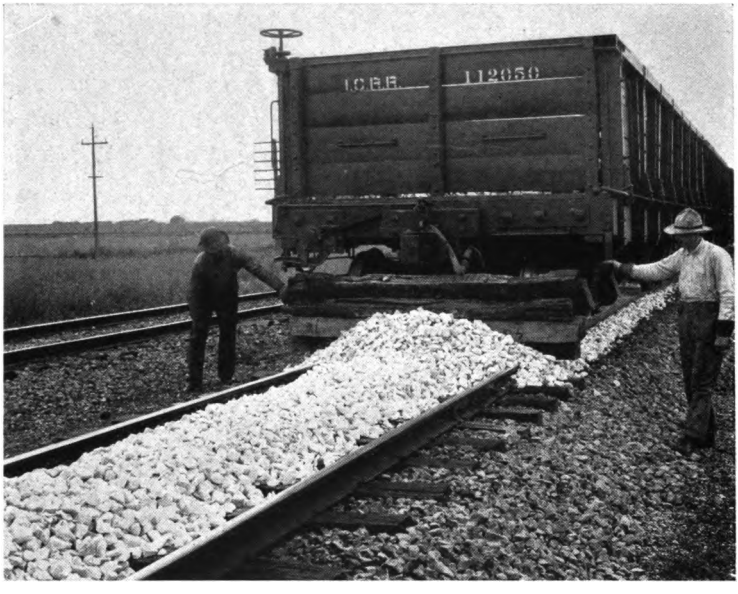


Fig. 27. Dapped timber being used to spread broken stone unloaded from center-dump cars.

when not in use the wings, or spreaders, may be folded out of the way, either against the side or on top of the car. Figs. 31 and 32 show another type of car for spreading ballast or earth and having some of the features mentioned above. Fig. 31 shows how the wings are placed when spreading, and Fig. 32 illustrates how the wings may be folded up out of the way when not in use.

ORGANIZATION OF FORCES

69. Any extensive work of ballasting requires a systematic organization of forces to efficiently carry on

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the work. It is impossible to give any outline of an organization suitable for carrying on work of this kind, that will not be subject to certain modifications, depending upon many conditions. Among these may be mentioned the density of traffic calling for the making of frequent run-offs to permit trains to pass, the varying quantities of ballast likely to be supplied, the depth of ballast to be placed under the track, and the requirements as to finishing and dressing. Consideration must also be given as to whether the operations are being carried on in connection

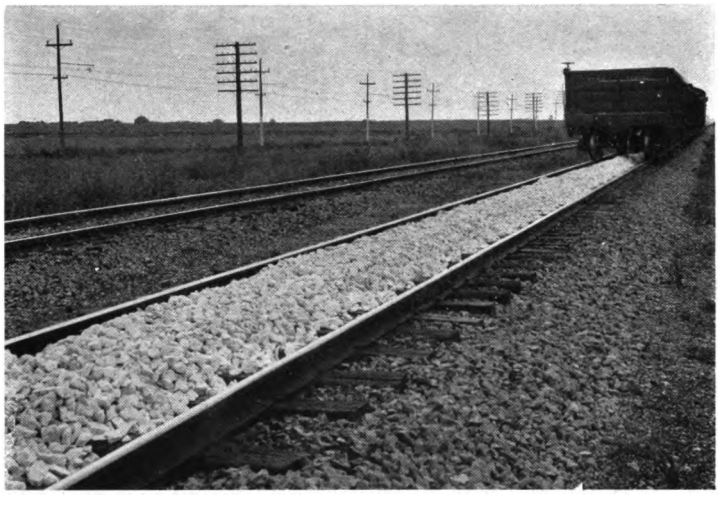


Fig. 28. Broken stone as unloaded from center-dump cars, before spreading.

with new track, or with old track that is being raised or reballasted.

70. On new work, gangs as originally organized are rarely broken up or their organization disturbed until the work for which they were provided has been completed; but organizations for special work such as the general raising of a section of old track may frequently be rearranged for numerous reasons which did not exist at the beginning of the work. It is therefore not possible to outline an organization for this work that could be regarded as fixed and not subject to change. Fewer men will be required to handle a certain quantity of *gravel* per month than will

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be necessary for the same quantity of *broken stone;* but owing to the varying conditions already mentioned, it is not possible to outline definite organizations for work of this kind, hence, the paragraphs following are offered as



Fig. 28 (*a*). Broken stone after spread by the arrangement shown in Fig. 27.

suggestions. The organizations there outlined represent the practice on two large systems.

71. When it has been determined how many cars of gravel are likely to be furnished daily for a certain piece of ballasting, the forces should be divided into separate gangs, to be assigned to particular branches of the work. For in-

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stance, such gangs may consist of an unloading gang, a raising gang, a lining gang, and a dressing, or finishing, gang—the size of each gang to depend upon the magnitude of the work. With from thirty to fifty cars of gravel, for instance, to be handled daily, the gangs may be organized about as follows:

Unloading gang: Foreman and fifteen laborers.

Raising gang: Foreman, track raiser, and sixty-five to seventy-five laborers.

Lining gang: Foreman and eight laborers.

Dressing or finishing gang: Foreman and thirty-five laborers.

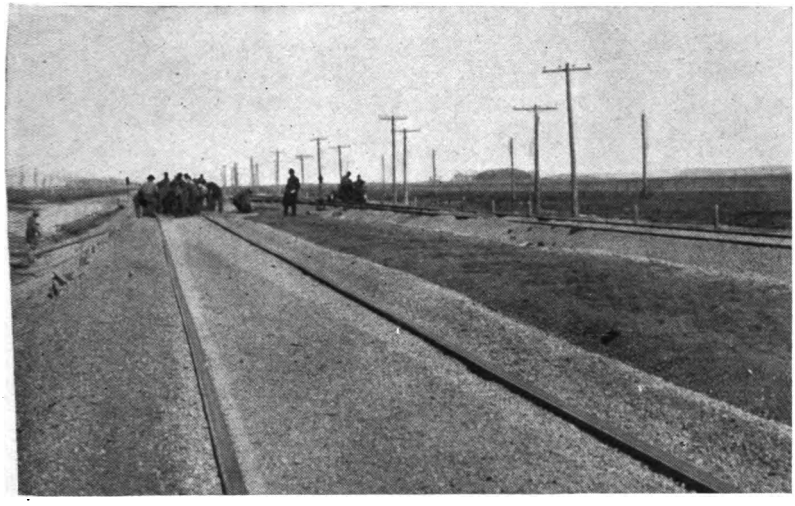


Fig. 29. Appearance of track after spreading the last run of Sherman gravel, by using the Rodger Ballast Plow.

Certain subdivisions of these gangs may be made to facilitate portions of the work, and such an organization of forces should complete about one-half mile of ballasted track daily.

72. Or, consider the following proposition: Suppose 20,000 cubic yards of broken stone ballast are to be handled monthly, and that the track has previously been ballasted with material other than broken stone, which is to be replaced by twelve inches of broken stone. Under average conditions the following organization will be efficient:

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Six gangs, consisting of a foreman and twenty-five men each.

Three gangs, consisting of a foreman and twenty men each.

One gang, consisting of a foreman and fifteen men.

73. These gangs should be assigned as follows: Two gangs, consisting of a foreman and twenty-five men each, should be placed at work digging out all of the old ballast, properly preparing the subgrade, and attending to the

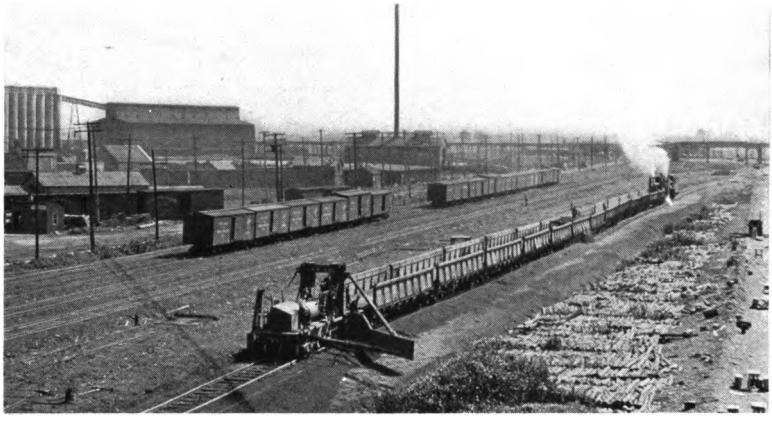


Fig. 30. A spreader car leveling earth discharged from work cars.

necessary tie renewals and respacing of ties. When ballast is to be unloaded, a foreman and ten of the men from these two gangs should be assigned to the unloading and spreading. Two gangs, consisting of a foreman and twenty-five men each, should be assigned to making the first raise of track; three gangs, consisting of foreman and twenty men each, should follow, making the second raise. Each of the foregoing gangs should do its own track lining. Two gangs, consisting of foreman and twenty-five men each, should devote their time to dressing the ballast and to taking out all remaining irregularities in line, surface and gage; and one gang, consisting of a foreman and fifteen men, should be assigned to making the sod line, when such practice is required, otherwise this gang can be dispensed with.

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74. As another example, suppose that 20,000 cubic yards of river gravel are to be handled monthly, the work consisting of reballasting track with six inches of gravel where it had previously been ballasted with other materials; then the organization may be about as follows:

Four gangs, consisting of a foreman and twenty-five men each.

Two gangs, consisting of a foreman and twenty men each.

Two gangs, consisting of a foreman and twenty-two men each.

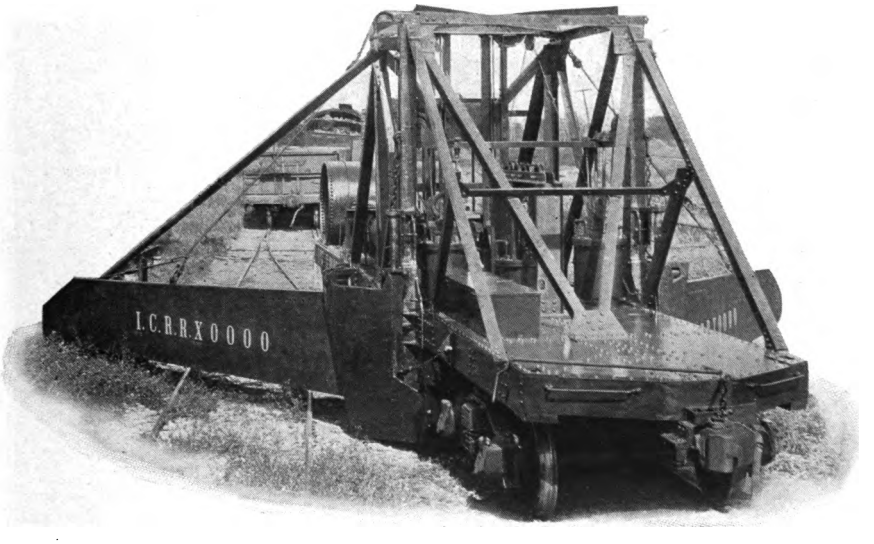


Fig. 31. A spreader car with wings set for spreading.

These gangs should be distributed as follows: Two of them, consisting of a foreman and twenty-five men each, should be assigned to taking out the old ballast, and properly preparing the subgrade. At the same time they should attend to all necessary tie renewals and respacing of ties. One of these foremen, with about fifteen men, should attend to unloading the ballast where necessary. Two gangs, consisting of a foreman and twenty-five men each, should be assigned to making the first raise. Two gangs, consisting of a foreman and twenty men each, should make the second raise, each of the foregoing gangs

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doing its own track lining. Two gangs, consisting of a foreman and twenty-two men each, should dress the ballast, taking out all small irregularities in line, surface and gage, and make the sod line where such is called for. Where this practice is not called for one of the gangs will be sufficient for finishing.

75. The equipment of tools enumerated in the following list, represents the average requirements of each gang composing the force engaged in handling river gravel as just described:

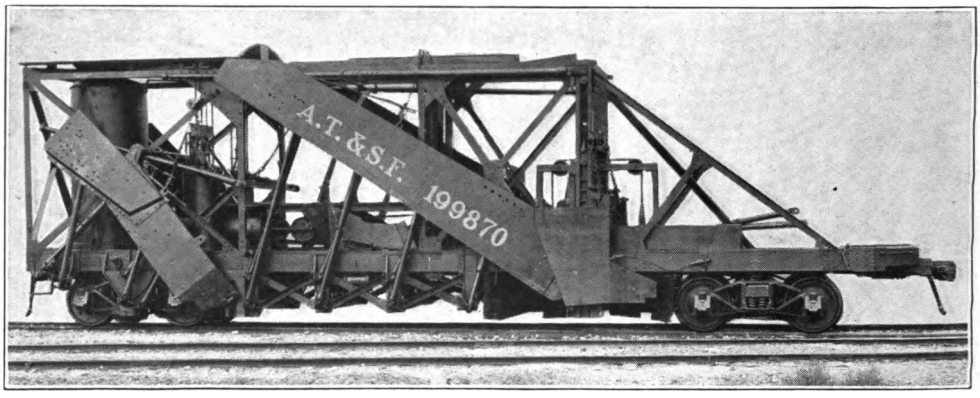


Fig. 32. A spreader car with wings folded as when not in use.

4 Adzes
1 Axe
4 Claw Bars
10 Lining Bars
12 Tamping Bars (except first four gangs)
2 Oil Cans (1 Gal. each)
1 Oiler (small)
3 Hand Cars
1 Push Car (except first two gangs)
6 Track Chisels
2 Water Pails
6 Tin Cups
2 Dump Boxes
6 Pick Handles (extra)
4 Track Jacks
1 Switch Key
3 Yellow Lanterns
3 Green Lanterns
2 Red Lanterns
6 White Lanterns
2 Extra Lantern Globes (of each kind)
1 Track Spirit Level
1 Tape Line
6 Spike Mauls
6 Clay Picks
200 ft. ¼-inch Rope
30 Track Shovels

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1 12-inch File
3 Metal Flags, Yellow
3 Metal Flags, Green
4 Cloth Flags, Red
2 Track Gages
2 Grindstones (for 8 gangs)
2 Adze Handles (extra)
1 Axe Handle (extra)
6 Maul Handles (extra)
1 Spot Board
2 12-inch Monkey Wrenches
6 Track Wrenches
1 Gallon Black Oil
1 Gallon Signal Oil
Torpedoes (according to amount of traffic—supply not to get below 36)
1 Spike Puller

Variations in the quantities or kinds of tools specified in the foregoing list, also in the signaling appliances, must be made to accord with the practices of each particular road. Only such tools as are actually required for the number of men expected to be at work should be called for. As soon as a gang is supplied with any surplus of tools beyond its actual needs, the liability of tools being lost or mislaid is increased. All tools should be kept in the best of repair at all times; those needing sharpening or dressing should be shipped to the proper repair shop to be placed in good order, as often as necessary.

TRACK PROTECTION

76. Any work that interferes with the safe passage of trains at their full speed is an obstruction to track, and track must never in any way whatever be obstructed, until it has been protected by the proper signals, as specified in the standard rule books of each road. Extra trains of which trackmen usually have no knowledge, may pass over the road at any time. Since the minor details of protecting track may vary on different roads, no attempt will be made here to definitely specify the protection to be afforded, but when general ballasting is being done, flagmen with proper signals must be stationed in accordance with the rules of the road. No foreman is competent as such who is not thoroughly familiar with his road's requirements in this respect, and as safety is more important than all else in railroad operation, foremen and several responsible men in their gangs should know what track protection means, and see that it is practiced whenever track work that will interfere with the passage of trains

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is being carried on. Red, green or yellow clothing may be mistaken for signals and such clothing should not be worn by trackmen or maintenance of way employes.

REVISING GRADE LINES

77. The grade lines of track are nearly always revised more or less when the matter of reballasting a piece of track is under consideration. The Engineering Department of every road has a profile of the roadbed which shows the existing grade, and when plans are being made to reballast track, the profile is carefully examined to ascertain whether the grade needs changing; that is, whether improvements cannot be made in parts of the track by cutting down certain high places, and raising others which are low. If it is thought best to change the grade, such changes are indicated by a line drawn on the profile, to show where the contemplated changes—raising or lowering —are to be made. When the grade decided upon has been established, engineers set grade stakes along the roadway in accordance with the indicated changes in profile. These stakes either bear a mark that shows the level for the top of rails, or are sawed off at a point corresponding to the top of rails, in which case the top of the stakes is the proper level. The stakes also bear figures when necessary to indicate cutting or filling.

78. Where much cutting down or filling must be done the most economical method should be considered. This may require the use of plows and scrapers operated by teams or the use of special grading machinery. The dirt removed is taken to places where needed, either by teams with drag or wheel scrapers, see Fig. 33, or, if the distance is too great for economical handling by teams, it is loaded on cars and hauled in work trains to places where it can be used to strengthen embankments or make a raise. On both single and double track, all dips of any consequence should be taken out on the old ballast. If the quantity of old material available for such purpose is insufficient, and more ballast cannot be had, then all of the old material should be put under the track and arrange-

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ments made to raise the bank with whatever other material is available.

PREPARATION OF THE SUBGRADE

79. The subgrade should be prepared with a slight crown at the center, sloping from the central point to the edge of the bank on each side. Methods of crowning the roadbed, or subgrade, vary. On one road the subgrade width for single track varies from 16 to 18 feet, depending on the height of banks, and is crowned 2 inches at the center. On double track, where the width of subgrade is 30 feet, the center is crowned 4 inches. In the case of



Fig. 33. Moving earth by means of drag scrapers.

four main tracks, the subgrade width is from 54 to 65 feet and the crowning is 6 inches. In order to secure an approximately uniform depth of ballast under all four tracks, the two center tracks in this instance are 2 inches above the others. The crowning in the foregoing example of practice is in the form of a flattened arc. In some cases the crowning is in the nature of two planes receding very slightly from the central point of the subgrade.

80. With a firmly compacted roadbed of good material, on which a sufficient depth of broken stone or slag ballast is to be laid, this crowning may be omitted, but the subgrade must at least be LEVEL; any concave surface that would collect and retain water is not allowable. Where

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one track is much higher than the other, it is impracticable to crown the subgrade until the low track has been raised on the old ballast to approximate the elevation of the other track; this should be done unless the difference in grade between tracks has been purposely made to reduce the grade against traffic in one direction. It is especially desirable when ballasting double track that both tracks be at the same elevation. This can generally be arranged by simply lifting the old track with the material on hand. But where there is much difference in the elevation, it becomes necessary to haul additional material. The final results obtained in finished track and the economy with which it may be maintained at high standard are governed largely by the manner of preparing the subgrade. A bad subgrade means bad drainage, and bad drainage means bad track sooner or later, regardless of the kind of ballast.

BALLASTING

81. When track has been properly prepared for the reception of ballast, enough should be unloaded to make the first raise. The same foreman with the same gang should always attend to the unloading, because it is necessary that the men be familiar with the arrangement and method of operating different types of ballast cars, to know from experience the proper distance to open hoppers, so that just the right amount of ballast will be unloaded and the expense of rehandling surplus quantities of ballast avoided; and to understand the proper handling of the Lidgerwood Unloader and plow, so as to prevent possible damage to equipment. Foremen and laborers who are assigned to the work of unloading should in all cases carefully examine the equipment which they have to handle and ascertain how the side doors, bottom hoppers and the various appliances with which ballast cars are equipped, are operated, before attempting to unload cars.

82. In the case of new track the subgrade is supposed to be in shape for the placing of the ballast. On old track to be reballasted, before any ballast can be distributed, it is necessary that part or sometimes all of the old ballast in the

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track be removed and the subgrade prepared for the new ballast. Often the old ballast need be removed only to the bottom of the ties. This is when track originally ballasted with some inferior material is to be raised on broken stone, slag, loose gravel or cinders, which is to be applied for the first time, or when the old ballast has become so mixed with earth or loam that it no longer provides suitable drainage around the ties, making reballasting necessary. In such cases the old material is removed usually to the bottom of the ties only, and that remaining under them used as a foundation for the new material. If the dirt between the ties is not removed before new ballast is placed, it soon becomes mixed with the ballast, and gradually works to the top at wet or low places in the track, causes "soft" track, increases the labor of general maintenance, and encourages a growth of weeds.

83. When broken stone ballast is dug out of the track preparatory to increasing the depth of the ballast under the track, the old ballast should be handled with ballast forks so as to screen from the stone any earth with which it may have become mixed. In fact broken stone and slag should always be handled with ballast forks so as to keep them free from dirt and rubbish. It is customary when cementing gravel is dug out of the track to be replaced by river gravel, to use the material formerly between the ties for raising the subgrade when allowable, or for strengthening banks.

84. Whether the amount of ballast unloaded is only a part of that required to complete the track, or whether the amount unloaded is sufficient to complete it, the first operation, after unloading, is to place the ballast under the ties. The method of actually placing the ballast is essentially the same whether the work is in connection with new line or with track being given a general raise throughout. Track is raised to permit placing ballast under the ties, by means of track jacks. These should always be placed outside of the rails and directly opposite each other, and both sides of the track should be raised at once. See

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Figs. 34 and 34 (*a*). The ballast is then forced under the ties and tamped.

85. Ordinarily about 100 feet of track is jacked up at once, but no more track should be raised at one time than can be tamped between regular trains. The raise should never exceed six inches at any one lift, another raise being made a few days later after traffic has passed over the track and the ballast become compacted enough



Fig. 34. The proper method of placing track jacks to raise track. The track level is also shown, as it should be used in such cases.

to show irregularities. The final raise can then be made in a similar manner. At each raise a run-off of sufficient length must be provided to make trains ride easily and to prevent bending of rails and joint connections. Jacks should not be used immediately at joints but about 2 feet to one side of them, so as to prevent breaking or bending the angle bars or joint connections, when raising. On some roads the practice is to raise one side of the track and tamp it, and then bring the opposite side to proper height by testing with a level. This is not considered the best practice, however.

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86. Several devices are used to assist in securing uniform surface when raising track. Some of these consist of various types of "targets" placed at a point on the track where it is at proper grade, and sighting blocks used at intermediate points to check the surface during raising. Probably the most used appliance of this kind is what is known as the SPOT BOARD. Spot boards are sometimes painted white with a black line running the entire length



Fig. 34 (*a*). Raising track, showing the use of spot board, jacks, and sighting blocks.

of the face of the board, or they may be painted so that the upper half of the face is white and the other half black. (See Fig. 34 (*a*).) Either method answers the purpose intended. SIGHTING BLOCKS are used in connection with the spot board, these blocks being equal in height to that part of the spot board which is painted black, or to the height that the top of the black line is from the bottom of the board if it is arranged that way.

METHOD OF USING THE SPOT BOARD

87. At some point in advance of the raising gang

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the spot board is placed level across both rails of the track and at right angles to it (see Fig. 34 (*a*)), with the bottom of the board as much above the top of the rails as it is desired to raise the track at that point. The spot board may be placed and leveled in proper position by means of offset blocks usually provided for that purpose, or by adjustable slide rods attached to the board, which can be moved up and down and tightened when the board is in proper position. At another point on the track which has already been brought to proper grade, a sighting block is placed on one of the rails (such a block can be seen in position on the left-hand rail, just beyond the man who is lying down and sighting in Fig. 34 (*a*)). The part of the track between this sighting block and the spot board is the section to be raised. The second sighting block is placed where the jacks are being used, on the same rail that the first block rests upon.

88. The foreman in charge of track raising now sights over the first block to the top of the black part of the spot board, as shown in Fig. 34 (*a*). Then the jacks are operated to raise the track, and when the top of the block at the jacks comes even with this line of vision, that point on the rail is at proper grade. The other rail can be brought up in the same manner. But the proper way is to bring up both rails at once, testing with a track level extending across both rails of the track where the jacks are being used; and as soon as one rail is brought to proper grade the opposite rail can be carefully brought level with it by means of the jack on that rail. (See Fig. 34.)

89. Since it is not advisable to raise track more than 6 inches at any one lift, and since track often requires a raise of 10 or 12 inches to bring it to proper grade, the spot board is in such cases set so that the bottom of the board comes as far below the top of the grade stake as the difference between the amount of the first raise and the total raise; in other words, if grade stakes indicate a required raise of 10 inches, and 6 inches of ballast is to be put under the track at the first raise, the spot board would be set so

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that the bottom would come 4 inches below the top of the stakes. (One of these stakes can be seen at the right side of Fig. 35, and a spot board placed somewhat as described, in Fig. 36. In this latter case one rail only can be brought to grade by sighting toward the spot board; the other must be brought to grade by aid of the track level. In this picture the level man is shown standing between the jacks.) The raising gang would then proceed to raise the track by using the spot board as already described, tampers being placed to work at the same point where the jack men are working, so as to tamp the new ballast firmly under the ties where the track has been raised to the proper height, according to indications of the spot board and level.

90. When raising is started, the spot board is usually placed about 300 feet in advance of the point where the foreman in charge begins the raising, and is moved ahead as often as necessary, the raising gang starting work with the jacks at the first joint where the track requires raising, and continuing from there to within about 75 feet of the spot board. Best results are obtained by not working closer than this distance to the spot board.

91. Jacks are usually placed at the joints (2 feet either side) and at centers of the rails. Their use at these points is usually sufficient to bring the intermediate points up to grade where heavy rails are in use. Sometimes it is necessary to use jacks on the quarters; that is, between joints and centers. This is when the rail is of light weight or when the ballast is wet and sticks to the ties badly.

TAMPING

92. It should be thoroughly understood that next in importance to a properly prepared subgrade is the importance of properly tamping the ballast. This feature of track work is often slighted. On the first raise of track all classes of ballast should be tamped with shovels, as shown in Fig. 35. Tamping bars and tamping picks are efficient only when the ballast first placed has become

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compacted so that subsequent material can be packed into a confined space. When placing ballast under new track or in reballasting where the raise calls for several inches of new ballast, the material must necessarily be put in loosely, and it cannot become generally compacted until trains have passed over the track for several days. In such cases the best and most rapid work can be done with the shovel.

93. No matter how carefully track may be tamped a tie does not sink uniformly throughout its length in the



Fig. 35. Tamping gravel on the first raise.

ballast, when carrying the load of traffic. It tends to assume a bowed shape usually causing a slight outward inclination of the rails. The thicker the ties, the less apparent this tendency, but the fact calls for much more thorough tamping at the ends of ties, 12 to 15 inches on each side of the rails, than at the center. Of course the ballast should be tamped throughout the entire length of the ties, at the same time the ends are tamped, that is, before commencing to tamp another tie; but under no circumstances should it be tamped more firmly at the middle than at the ends at the last tamping, or when making the last raise. This would cause track to become what is known as "center-bound," and this condition with the

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consequent rocking of track due to the lateral (side) thrust of trains is very destructive to line and surface. In fact ties may be broken at the center and spreading track be a consequence.

94. Although tamping must be thoroughly and uniformly done when making the first raise, no attempt is made to do a finished job as regards cleaning up and dressing the track. Trains are usually allowed to run over the track for several days after the first raise has been made, in order to firmly compact the ballast and show up any weak spots that unintentionally may have been neglected.

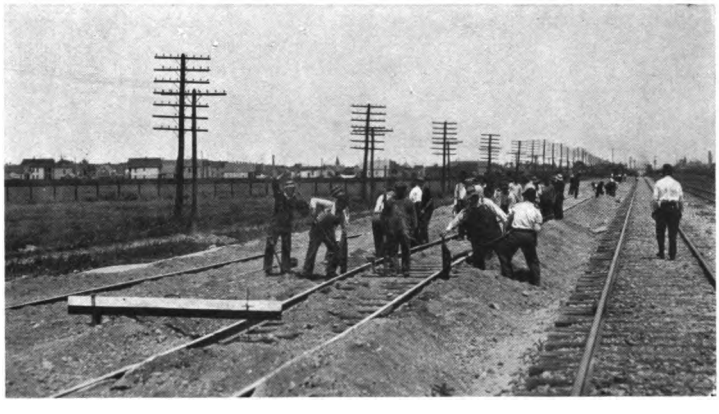


Fig. 36. Raising track and tamping.

95. The men tamping ballast should work in pairs on opposite sides of the tie being tamped (except as later noted), both men operating their tamping tools simultaneously so that the ballast may actually be packed *under* the tie, instead of against it, or forced under and then out again on the opposite side. The knack of using tamping tools properly, especially the use of the shovel in tamping, is acquired only after some little practice. It is supposed that the foreman in charge of this work is a man thoroughly experienced in its actual performance, and he should show each of his men how the work is to be done. Until the inexperienced have been given an actual demonstration of proper shovel tamping, it will be found that most men

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will dig down to or into the subgrade, and pack the ballast *against* the ties instead of *underneath* them.

96. Much economy of time will result from dividing the tamping gang into squads, and assigning to each squad the tamping of half a rail length of ties, for instance, and when the tamping of these has been finished the entire squad should move ahead and take a similar section on another rail length. This will prevent the men from wast-



Fig. 37. Proper method of using tamping bars.

ing time wandering about under pretense of finding the next place to resume tamping. Shovel tamping is done on both sides of the tie at the same time. Four men working as two pairs on opposite sides of the ties tamp the ends outside the rails, while four men working as two pairs tamp opposite sides of the ties between rails.

97. While shovel tamping is allowable and even preferable when making the first raise it is not permissible on the second raise. At this stage of the work other tamp-

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ing tools must be used. For broken stone and slag the tamping pick is best, and some roads require that final tamping of cementing gravel also be done with tamping picks. As a general thing, however, gravels and materials other than stone and slag are tamped on the last raise by using tamping bars. In using tamping bars the men should work in pairs opposite each other, as shown in Fig. 37, striking in unison so that the ballast will not be forced out at the opposite side of the tie; but when using tamping picks they must work as shown in Figs. 38 and 38 (*a*). Considerable practice is required to use the tamping pick prop-



Fig. 38. Tamping and surfacing on broken stone ballast.

erly so as to produce uniformity in the tamping. It is very easy to wedge track up above the proper surface when tamping with picks.

98. Joint ties should always be tamped first, then the ties next to the joints, known as shoulder ties. It is customary to tamp these somewhat harder than the remainder of the ties owing to the tendency of downward bending at the joints, but in no case should these ties be tamped so as to bring the joints above the general surface. A poorly tamped joint tie will cause such deflection under

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traffic that the joint connections will soon be bent or broken. This bending tendency is not so marked with some of the latest forms of rail joint connections, however, as was common when the ordinary types of angle bars were in universal use.

99. The section of track where a switch is installed is one of the most important parts of a piece of main-line track, and in order that switches may be maintained in a



Fig. 38 (*a*). Proper way in which to tamp with tamping picks.

safe condition, ballast under all switch ties must be firmly tamped to provide a firm bearing for the track. This is especially true at the head block carrying the switch stand, and of all ties under the point and heel of the switch, and of ties under the frog. It would be preferable always to tamp switch locations by using tamping picks or bars, instead of shovels.

100. When placing and tamping ballast on curves, it is necessary to give a specified elevation to the outer rail of the track, usually indicated on the grade stakes; and

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foremen should carefully check the surface of curves to know that the proper elevation has been provided. It is also important when raising track to get instructions from the proper officer as to the requirements of raising through tunnels, snow sheds, under overhead bridges, and along water tanks, coal chutes, freight and passenger platforms, etc. In tunnels, snow sheds, and under overhead bridges, a certain clearance is maintained, and when this has once been established, no change is permissible except on proper authority. The same authority should be obtained before raising track in the vicinity of the other structures mentioned, for reasons which are similar and self-evident.

FINISHING AND DRESSING

101. There is considerable difference of practice among various roads as regards the dressing of cross sections and the general finishing of track. Most rule books containing the rules and regulations which each road issues, specifying the requirements of its roadway and track department, contain illustrations of various track standards, among which are standard ballast cross sections for the several ballast materials in use on the particular road, and students should familiarize themselves with the standards of their road. The Roadmaster or Track Supervisor is the official who can supply the necessary information.

102. After the second raise has been made and traffic has passed over the track for several days, it is ready for finishing. This includes taking out all irregularities that have shown up in surface, line and gage, also filling in the track so that the ballast conforms in cross section to the road's standard, and, when called for, making a sod line. All of this work is attended to by finishing gangs. Wherever it is necessary to correct any irregularities in surface, all tamping required must be done with tamping bars or picks, according to the class of ballast.

103. When the final irregularities of line and surface have been corrected the track is filled in and dressed.

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The manner of doing this depends greatly on the nature of the ballast used, but dressing track is a detail that should be given very careful attention. The method of filling in the track has been shown by preceding illustrations and the description of cross sections was given in paragraph 37, and paragraphs 41 to 47, inclusive. Dressing consists of giving a uniform width of shoulder to the track, by rounding or sloping it as called for by the road's standards, forming a neat, true toe line at the slope, and making a sod line where the standards require it. All surplus ballast must be cleaned up, and if it can be used at nearby points, must be removed to such places for use. Ordinarily such moving of surplus quantities can be done by push cars equipped with dump boxes. But when the distance exceeds 600 feet it is usually cheaper to remove any considerable quantity by loading on flat cars and hauling by work engines.

104. In general it may be said that track ballasted with broken stone, loose pit gravel, slag, and similar materials should be filled in to the tops of the ties between rails, but not any above the ties. There should be a free space under rail flanges sufficient to just clear the rail base, or about the space necessary to insert a shovel blade, and this level should prevail to the end of the tie. When the ballast is placed even with the rail base, or against and the least bit above it, sand or dirt will be blown or will lodge against the rail, work into the ballast, and eventually result in water being retained between the rails. In other words, free drainage is impeded, and the consequent track troubles are multiplied, especially during freezing weather.

105. It is the practice on some roads to slope the ballast immediately from the ends of the ties to the subgrade, but in most cases it will be found that better line can be maintained on track ballasted with stone, slag, etc., if a shoulder of at least 6 inches is formed beyond the ends of the ties and the slope of the toe line made from the point of this shoulder. Of course, this practice calls for more ballast, but is preferable for the reason mentioned.

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106. The dressing of all ballast materials like stone, slag, disintegrated granite, etc., which drain freely, is done partly to give an attractive appearance to finished track. In such materials as cementing gravel, ordinary earth, and sometimes sand, the dressing must be primarily to insure that the quickest possible surface drainage is secured. This makes it impracticable to shoulder out these ballast materials to give a specially attractive appearance, and requires that track ballasted with them be filled in usually above the ties at the center and a slope made from the center to the bottom of the ties at their ends, or at least not more than an inch above their bottom. Heaping the ballast above ties in the center of track compensates in a measure for the absence of shoulder to hold track in line, but such practice is followed only because necessary, as when a road is compelled to use an inferior ballast.

107. There are various types of track shouldering machines, constructed and operated in a manner similar to the side ballast spreader described in paragraph 68, which are sometimes used to form a shoulder to track or to "edge" the roadway bank. These devices have but a limited use in the actual dressing of ballast, their principal utility being in shaping or shouldering embankments that have been widened, and in leveling material deposited for a new parallel track. The device illustrated in Figs. 31 and 32 is adjustable for such usage.

108. Where there is double track main line and the ballast has a tendency to hold water, it is necessary to provide a ditch or other drainage facilities between tracks. Cross drains from the central ditch lead from it and pass under the track at intervals to the side ditches. Such drains should be placed deep enough so they will not be disturbed when making tie renewals, tamping ballast and doing other track work.

109. The subject of drainage which has only been mentioned casually at certain places in this lesson, is such

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an important one that it will be made the subject of a subsequent lesson in the TRACK COURSE.

110. Figs. 39 and 40 show the appearance of properly dressed track. It is clean, free from weeds and other rubbish, and a neat sod line has been made. Such track is quickly noticed and favorably commented upon by travelers, whereas it might not attract their attention simply

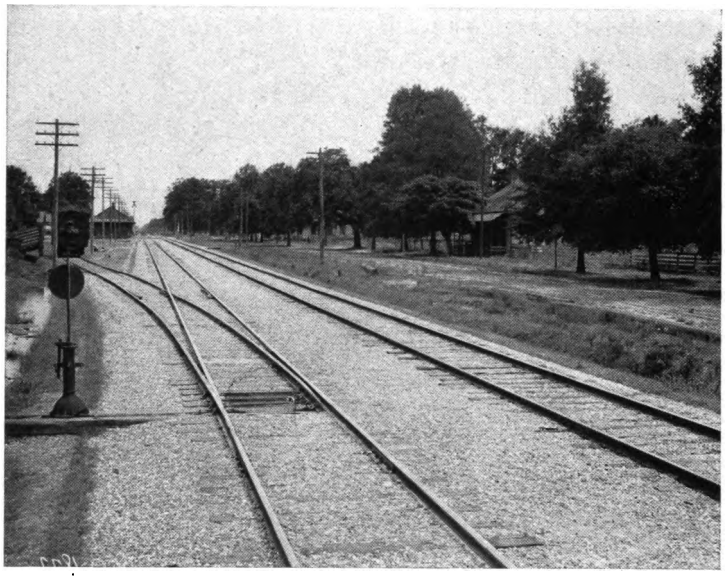


Fig. 39. Properly maintained double track on gravel ballast, showing standard maintenance at switch, neat sod line and fine appearance generally.

through possessing good riding qualities, although, of course, proper line and surface are of utmost importance.

111. When opening ballast pits, rectifying grades, doing extensive ballasting or other work that requires extra forces, it is necessary to provide good sleeping, living and other requisite accommodations for the men. Usually, box cars that are not fit for regular traffic service, are fitted up for this purpose. Such cars are usually arranged to provide quarters for eight men. Comfortable bunks should be constructed, the roofs of cars should be

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put in good order, and suitable light and ventilation provided. These cars should be ceiled to make them warm, and be given two heavy coats of paint containing a liberal quantity of turpentine. When extra gangs are to be located at some point on work requiring several months for its completion, temporary bunk houses are often constructed; these usually make more satisfactory quarters than can be provided by adapting old cars to such use.

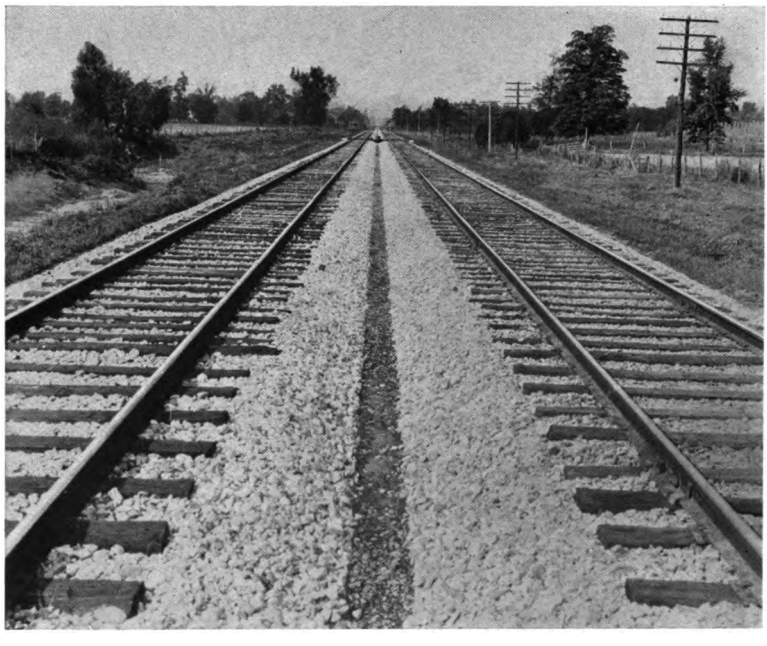
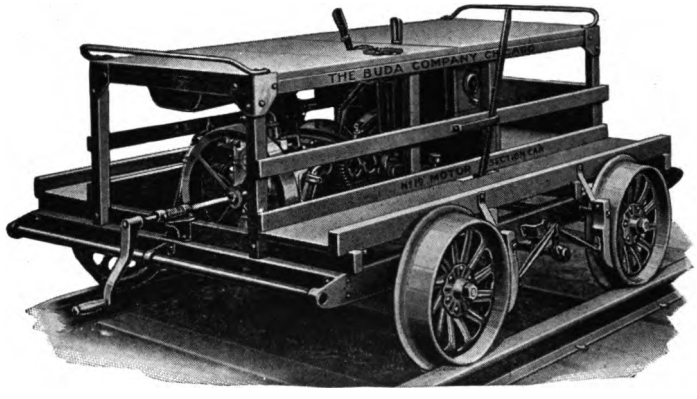


Fig. 40. Properly maintained double track on crushed rock ballast. A piece of track a section man should be proud of.

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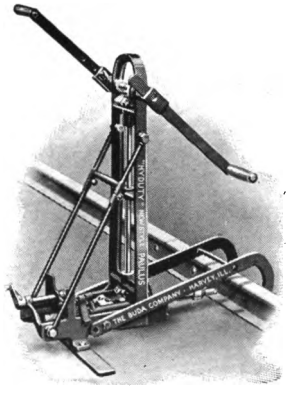
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HART CONVERTIBLE CARS

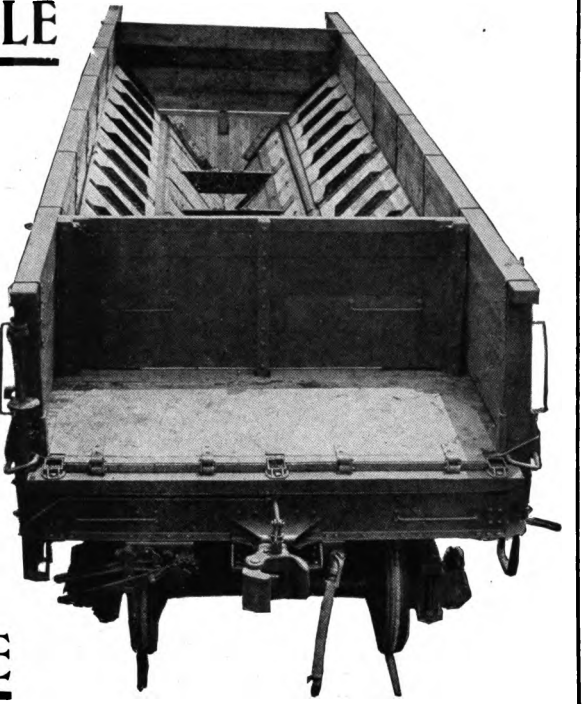
Center Dump

Side Dump

and

Flat Bottom Gondola

ALL IN ONE



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OPERATING THE HART CONVERTIBLE CAR

BEFORE LOADING, cars should be turned if necessary, so that all of the controlling levers will be on the same side of the train, thus making it unnecessary to climb over the train, from one side to the other, while unloading.

TO PROVIDE FOR CENTER DUMPING, the car should be arranged before loading, as follows:

1. Remove the center sill from below the floor doors and place it on the floor against the car sides.
2. Swing the floor doors up against the car sides to make the hopper.
3. Move the end gates into the ends of the hopper and fasten them with the means provided.
4. Close the hopper door tightly, using the operating lever and ratchet to turn the winding shaft, then lock the door by using the detent lever with cam lock.
5. Disengage the operating lever pawl and ratchet. (Do not use the operating lever and pawl to hold the door closed. They can not be readily disengaged when the weight of the load is upon the door.)

When the foregoing operations have been taken care of, the car is ready to load.

When the loaded train reaches the point at which ballast is to be unloaded and distributed, the plow car should be picked up and placed between the last car of the train and the caboose.

One man who is familiar with the operation of the plow, preferably the rear end brakeman, should be placed in charge of it.

THE PLOW SHOULD BE LOWERED UNTIL IT RIDES ENTIRELY UPON THE RAILS; then the lifting wheel should be given several more turns until the screw has an inch or more of play to provide for free movement of the plow over uneven track.

As mentioned in the text of this lesson, unloading should be in charge of those who are familiar with the operation of cars. OPERATING THE CARS requires but one man and very little effort. Experience has shown that the best results are obtained when the conductor of the train personally attends to the unloading.

UNLOADING SHOULD BEGIN WITH THE CAR FARTHEST FROM THE PLOW that is, the car back of the locomotive. Turn up the DETENT LEVER CAM LOCK and simply work this lever up and down. This allows the winding shaft to rotate one notch at a time, and opens the hopper door slowly. When the door has been opened to about 8 inches, or sufficient to cause the flow of ballast to fill the track nearly up to the ball of the rails, the hopper door should be locked at the proper opening by means of the DETENT LEVER and its CAM LOCK.

Start the train at once and keep it moving at a speed of about three miles per hour, or at easy walking speed.

The conductor, or whoever is operating the release of hopper doors should drop back to the second car and be ready to open it in the same manner. This should not be done until the second car has passed over the ballast deposited by the first car, so that the discharge will commence at and lap over just where the unloading of the first car ended. This to insure that there will be no space left between rails without ballast. Following cars should be unloaded in the same manner.

NEVER OPEN TWO CARS AT ONCE, and DO NOT STOP THE TRAIN WHILE CARS ARE DISCHARGING.

Do not attempt to put in on the first run all of the ballast required unless unloading for a slight raise. ADJUST THE HOPPERS so that the discharge at first is light, and gradually increase the hopper opening until the discharge equals all that the track will hold, or a lesser quantity if desired. From 1,000 to 1,200 yards per mile on the first run is equivalent to a four o·

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five inch raise. If more ballast is required, make another run over the same section of track. Two or three train loads can be unloaded and spread before lifting track if desired, but each train load must, of course, be plowed off before the next run is made.

PRACTICE BRINGS SKILL. By going slowly at first, the men in charge of unloading will quickly acquire judgment as to how far to open hopper doors, how fast to run the train, etc.

DO NOT ALLOW TAMPING GANGS OR SECTION GANGS TO JUMP ON THE CARS AND TRY TO OPEN THEM. They more often than otherwise make trouble and do poor work, by getting cars off the track, leaving spaces without ballast, opening two cars at once and stalling the train, etc.

WHEN THE PLOW CAR REACHES THE UNLOADED BALLAST the plow must be down upon the rails as previously described. It will then clean the track and act as a flanger alongside the rails.

CARE SHOULD BE TAKEN IN OPERATING THE PLOW, to watch for highway crossing planks, guard rails, frogs and switches, so that the plow can be raised an inch or more while passing over these places in the track to avoid catching and breaking it. After passing such obstructions it should at once be lowered as before.

WHEN SPREADING HAS BEEN FINISHED the plow should be raised up to the sills of the car and locked by the iron key provided, to keep it steady while the train is running. The plow should be raised by means of the worm screw, just far enough so that the weight will be equally carried by the key and the screw.

Guides in which the plow is raised and lowered must be kept well oiled with heavy black oil, so that the plow will move freely to insure that it rides upon the rails when unloading.

Regardless of who may operate the plow car, a brakeman should always be with the car when unloading.

DIRECTIONS FOR CONVERTING HART CONVERTIBLE CARS FROM CENTER-DUMP TO SIDE-UNLOADING CARS

1. Turn the apron on the end of the car over onto the next car.
2. Remove the tie bolts which fasten the movable end gates to the top plates.
3. Remove the end gates from the car.
4. Withdraw the movable sill, which will be found under the convertible floor doors, and place it in the center of the car.
5. Turn down the convertible floor doors. Before doing this be careful to remove all pebbles, dirt, or other matter from the top of the sills so that the doors will lie flat.

TO CHANGE FROM SIDE-DUMP TO GONDOLA CAR

The operations to be performed for this purpose are the same as the foregoing, except that the apron is left upon the floor of the car to which it is attached, and the movable end gates placed in their proper position in the ends of the car.

TO CHANGE FROM SIDE-DUMP TO CENTER-DUMP ARRANGEMENT

1. Turn up the center convertible doors.
2. Take out the movable center sill from the center of the car and place it under the convertible doors.
3. Place the movable hopper end gates into their proper position at the ends of the hopper, and replace the tie bolts through the plates and movable end gates.
4. Turn the apron over onto the floor of the car to which it is attached.

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